DOCUMENT RESUME

ED 282 743 SE 048 166

TITLE	The Energy Sourcebook.
INSTITUTION	Tennessee Valley Authority, Knoxville.
REPORT NO	TVA-OP-C&EM-86-99
PUB DATE	Oct 86
NOTE	511p.; Developed and tested by high school teachers in the Tennessee Valley.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF02/PC21 Plus Postage.
DESCRIPTORS	Alternative Energy Sources; Electricity; *Energy Conservation; *Energy Education; *Environmental Education; Fuels; High Schools; *Interdisciplinary Approach; Natural Resources; Nuclear Energy; *Science Activities; Science and Society; Science Instruction; *Secondary School Science; Solar Energy
IDENTIFIERS	*Tennessee Valley Authority

ABSTRACT

Teachers in the Tennessee Valley region, working in cooperation with the Tennessee Valley Authority's (TVA) network of university-based centers and cooperatives for environmental/energy education developed this sourcebook of energy education materials for grades 9-12. The materials were intended to supplement a variety of high school disciplines. Six energy topics that are specific to the Tennessee Valley are addressed: (1) solar energy applications; (2) electricity produced by hydropower; (3) nuclear generators; (4) coal-fired generators; (5) energy conservation; and (6) alternative energy sources are each presented in a separate section of the document. Each section begins with a brief overview which provides background information, including some historical information, descriptions of current technologies, and environmental concerns relative to the production and use of that resource. Following each overview are classroom activities to enhance the basic understanding of that particular energy resource. A "special projects" section describes research activities, construction projects, field experiences, and computer programs developed by individual teachers. The final section provides activities that use special equipment and models available from TVA's seven district power offices. (TW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED282743

THE ENERGY SOURCEBOOK

SE 048 166

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Judy A. Driskell
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

BEST COPY AVAILABLE

THE ENERGY SOURCEBOOK

Developed and Tested By:

High School Teachers in the Tennessee Valley

In Cooperation with the:

TVA Network of University-based centers and cooperatives for Environmental/Energy Education at:

Cedar Creek Learning Center, Greeneville, Tennessee
Jackson State University, Jackson, Mississippi
Memphis State University, Memphis, Tennessee
Murray State University, Murray, Kentucky
University of Alabama in Huntsville, Huntsville, Alabama
University of Tennessee at Chattanooga, Chattanooga, Tennessee
Western Carolina University, Cullowhee, North Carolina
Western Kentucky University, Bowling Green, Kentucky

Sponsored by:

Tennessee Valley Authority

- Consumer Outreach Section, Office of Power
- Environmental/Energy Education Program, Office of Natural Resources and Economic Development

For more information contact the Citizen Action Office. Call toll free 1-800-362-9250 (Tennessee), 1-800-251-9282 (Alabama, Arkansas, Georgia, Kentucky, Mississippi, Missouri, North Carolina, and Virginia), 632-4100 (Knoxville area) or write Tennessee Valley Authority, Citizen Action Office, 400 West Summit Hill Drive, Knoxville, Tennessee 37902.

DISCLAIMER

This document was prepared for the Tennessee Valley Authority (TVA) by teachers in the Tennessee Valley in cooperation with the Consumer Outreach Section and the TVA Network of University-based centers and cooperatives for Environmental/Energy Education. Neither the preparers, TVA, nor any persons acting on their behalf:

a. make any warranty or representation, expressed or implied, with respect to the use of any information contained in this document, or that the use of any information, apparatus, method, or process disclosed in this document may not infringe on privately owned rights; or

b. assume any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this document.

This document does not necessarily reflect the views and policies of TVA. The use of specific brand names or products should not be construed as an endorsement by TVA.

TVA is an equal opportunity and affirmative action employer. TVA also ensures that the benefits of programs receiving TVA financial assistance are available to all eligible persons regardless of race, color, national origin, handicap, or age.

TVA/OP/C&EM-86/99

TVA gratefully acknowledges the time and energy of the teachers, students, and university-center directors and staff who participated in the development of The Energy Sourcebook.

Dan Barnett
Greene County Schools
Greeneville, Tennessee 37743

Ken Barrett
Russellville High School
Russellville, Kentucky 42276

Linda Barrett
Camden Central High School
Camden, Tennessee 38320

Gary Barrigar
Elizabethton High School
Elizabethton, Tennessee 37643

Evelyn Bell
West Greene High School
Greeneville, Tennessee 37743

Jim Black
Monte Sano Environment Center
Huntsville, Alabama 35801

John Black, Principal
Tanner High School
Tanner, Alabama 35671

Jean Booker
Bowling Greeen High School
Bowling Green, Kentucky 42101

Becky Booth
Memphis State University
Memphis, Tennessee 38111

Brenda Brock
Tanner High School
Tanner, Alabama 35671

Alicia Brown
Sedalia High School
Mayfield, Kentucky 42066

Marcus Burkes
Alternative School
Jackson, Mississippi 39206

Brenda Call
Calloway County High School
Murray, Kentucky 42071

Roy B. Clarianna
Memphis State University
Memphis, Tennessee 38111

Micheal T. Clark
Lone Oak High School
Paducah, Kentucky 42001

Mary Clemens
Pisgah High School
Dutton, Alabama 35744

Jewell Colliver
Barren County High School
Glasgow, Kentucky 42141

William R. Cranford
Jackson Central-Merry High School
Jackson, Tennessee 38301

Dottie Dale
Huntsville High School
Huntsville, Alabama 35801

Cheryl P. DeVivo
East Ridge High School
Cattanooga, Tennessee 37411

Dee Eiklor
Sullivan South High School
Kingsport, Tennessee 37664

Becky Fairbanks
Fulton City High School
Fulton, Kentucky 40241

Sally D. Ferguson
South Fulton High School
South Fulton, Tennessee 38257

Rita Griffin
Natchez Trace Academy
Madison, Mississippi 39110

Carol Hammons
Tanner High School
Tanner, Alabama 35671

Susan Harris
Huntsville High School
Huntsville, Alabama 35801

Lloyd Hasty
Murray High School
Murray, Kentucky 42071

Pat Henderson
Breckinridge County High School
Harden, Kentucky 42048

Barbara Hill
Owensboro Catholic High School
Owensboro, Kentucky 42301

Douglas C. Jenkins
Warren Central High School
Bowling Green, Kentucky 42101

Ina Jenkins
Huntsville High School
Huntsville, Alabama 35801

Michael Jones
Pisagh High School
Waynesville, North Carolina 28786

Angela F. Lee
Red Bank High School
Chattanooga, Tennessee 37415

Dannie McCarley
Muscle Shoals High School
Muscle Shoals, Alabama 35661

Guy Y. McClure
Athens High School
Athens, Alabama 35611

Linda McIntosh
Knight Road Elementary
Memphis, Tennessee 38118

Steve Merideth
Russellville High School
Russellville, Kentucky 42276

Peggy Mervine
Franklin-Simpson High School
Franklin, Kentucky 42134

Joe Milam
Russellville High School
Russellville, Kentucky 42276

Sheryl Milam
Russellville Middle School
Russellville, Kentucky 42256

Walter Mojsejenko
Owensboro Catholic High School
Owensboro, Kentucky 42301

Ruth Morgan
Warren Central High School
Bowling Green, Kentucky 42141

Liz Morrell
West Greene High School
Greeneville, Tennesseee 37743

Larry Morrow
Trimble County High School
Bedford, Kentucky 40006

Roy Mosier
Russellville High School
Russellville, Kentucky 42256

Brenda Motley
Huntsville High School
Huntsville, Alabama 35801

Stanford N. Peppenhorst
Germantown High School
Germantown, Tennessee 38130

Joan M. Perry
Owensboro Catholic High School
Owensboro, Kentucky 42301

Carolyn Ratledge
South Greene High School
Greeneville, Tennessee 37743

Jim Reilly
Trimble County Middle School
Bedford, Kentucky 40006

Howard L. Rhodes, Jr.
Bradshaw High School
Florence, Alabama 35630

Betty Richerson
Muscle Shoals High School
Muscle Shoals, Alabama 35661

Sister M. Leon Riney
Owensboro Catholic High School
Owensboro, Kentucky 42301

Thadene Roberts
Tanner High School
Tanner, Alabama 35671

Ron Robertson
Dickson County Senior High School
Dickson, Tennessee 37055

Tim Ross
Russellville High School
Russellville, Alabama 35653

Barbara Schaum
Trimble County Middle School
Bedford, Kentucky 40006

Mary Stanton Seay
Mayfield High School
Mayfield, Kentucky 42066

James Sellers
Lone Oak High School
Paducah, Kentucky 42001

Billy Sensing
Lone Oak High School
Paducah, Kentucky 42001

Cheryl M. Shelton
Brewer High School
Somerville, Alabama 35670

William Jerry Shelton
Murray High School
Murray, Kentucky 42071

Dee Smalley
Colonial Junior High School
Memphis, Tennessee 38111

Amy M. Smith
Collierville High School
Collierville, Tennessee

Carol Smith
University of Tennessee
Knoxville, Tennessee 37916

Joseph P. Stewart
Warren East High School
Bowling Green, Kentucky 42101

Mary Thomaskutty
Brewer High School
Somerville, Alabama 35670

Don Travis
Bowling Green High School
Bowling Green, Kentucky 42101

Randy Wadell
South Greene High School
Greeneville, Tennessee 37743

John Keith Waggoner
Northwest Whitfield High School
Flintstone, Georgia 30725

James S.Watson
Red Bank High School
Chattanooga, Tennessee 37415

Jana M. Whitt
Bowling Green High School
Bowling Green, Kentucky 42101

Jo Wigington
Huntsville High School
Huntsville, Alabama 35801

UNIVERSITY CENTERS AND COOPERATIVES

Center for Environmental/Energy and Science Education — (601) 968-2189
Jackson State University
Jackson, Mississippi 39217
Dr. Grover D. Barnes, Director
Linda Annette Sanders, Project Assistant

Center for Environmental, Energy and Science Education — (615) 755-4237
University of Tennessee at Chattanooga
Chattanooga, Tennessee 37402
Dr. Bernard Benson, Director
Margaret J. Baty, Project Assistant

Center for Environmental/Energy Education — (704) 227-7476
Western Carolina University
Cullowhee, North Carolina 28733
Dr. Richard C. Berne, Director
Kelly Roepke, Project Assistant

Center for Mathematics, Science, and Environmental Education — (502) 745-4424
Western Kentucky University
Bowling Green, Kentucky 42101
Dr. Glenn H. Crumb. Director
Cynthia Faye Davis, Project Assistant
Joan Martin, Project Developer

Center for Environmental and Energy Education — (901) 454-2545
Memphis State University
Memphis, Tennessee 38152
Dr. Ron Cleminson, Director
Roy B. Clarianna, Project Assistant

Johnson Research Center, Environmental & Energy Education Program — (205) 895-6257
University of Alabama in Huntsville
Huntsville, Alabama 35899
Mr. Bernard Levine, Director
Rhonda E. Berryman, Dave Brotherton, Hethalyn Godwin, Claylia Heilman, Angela Eyman, Becky Spin, Dawn Ryan, Amy Werkheiser, Project Assistants

Cedar Creek Learning Center — (615) 639-4194
Greene County Schools
Greeneville, Tennessee 37743
Mr. Douglas Ratledge, Director
Violet Carlos, Project Assistant

Center for Environmental Education — (502) 762-2747
Murray State University
Murray, Kentucky 42071
Mr. Terry Wilson, Director
Rodney L. Johnson, Project Assistant

TABLE OF CONTENTS

Acknowledgements i
Table of Contents v
Introduction viii

SOLAR
Overview S-1
The Sun in Mythology and History S-4
Tracing the Flow of Solar Energy S-7
Purifying Water with Sunlight S-18
The Influence of Color on Heat Absorption S-21
Measuring the Number of Calories in Sunlight S-24
Making a Flat-Plate Collector S-29
Improving the Efficiency of the Solar Collectors S-34
Testing the Electrical Output of Solar Cells S-39
Measuring the Heat of a Solar Collector Using a Thermocouple . . . S-46
A Solar Community S-52
Glossary S-54
References S-58

CONSERVATION
Overview C-1
To Conserve or Not to Conserve C-4
Energy-Efficient Structures C-44
The Electric Hookup C-64
Recycling C-72
Cutting Cost with Clothing C-78
Energy Efficiency in Nutrition C-82
Glossary C-84
References C-89

HYDROPOWER
Overview H-1
To Build or Not to Build H-3
A Home-Made Water Turbine H-12
Gristmills: Water Wheels of Yesterday H-18
Aquatic Habitats in Reservoir and Stream Ecosystems H-20
Calculating the Potential Energy of Flowing Water H-37
Generate Your Own Hydropower H-42
Glossary H-49
References H-52

COAL

Overview CL-1
Coal and Geologic Time CL-3
United States Coal Deposits CL-8
Recovering, Processing, and Utilizing Coal CL-13
Measuring Heat Energy CL-17
Coal and Water CL-22
Acid Rain CL-26
Reclaiming Lands CL-31
Making Decisions CL-34
Glossary CL-39
References CL-42

NUCLEAR

Overview N-1
The Inverse Square Law N-3
Nuclear Plant: Who Decides? N-12
A Sign of the Times N-18
Decaying Dots N-30
Nuclear Pursuit N-35
Fuel Cycle N-49
Power Plant Cycle N-51
The Effect of Radiation of Chromosome Structure N-59
Radioactive Decay N-61
What is Radiation? N-63
Glossary N-67
References N-70

ALTERNATIVE ENERGY SOURCES

Overview AE-1
Is it to Late? AE-5
Wood for Heating AE-19
Power of Wood AE-26
Alcohol as an Alternative Fuel AE-33
Biomass Alternatives AE-37
Waste Incineration Demonstration AE-49
Wind Energy - Measuring Wind Speed AE-55
Is There an "Ultimate" Energy Source AE-65
Glossary AE-72
References AE-77

SPECIAL PROJECTS

Overview SP-1
In Charge SP-2
Introduction to Energy Sources and Use SP-3
Alternative Energy Technologies SP-3
Spent Steam SP-4
Do Windbreakers Conserve Energy? SP-4
The Sunbox Project SP-5
The Solar Oven Project SP-5
Waste Energy? Not Me! SP-6
Yesterday's Yardstick - Tomorrow's Technology SP-6
Good to the Last Drop SP-7
Wiring Switches for Energy Conservation SP-7
Electrical Energy - A Trip to Paradise SP-8
Solar Energy Simulation SP-8
Photovoltaic Stimulation: A Process to Increase Plant Growth . . . SP-9

EQUIPMENT AND MODELS

Overview . . . . E&M-1

BICYCLE GENERATOR

Work is Energy BG-1
The Bicycle as a Machine BG-4
Power BG-7
Power in Electric Circuits BG-10
Energy: Changes in Form BG-13
What Appliances Can Be Powered by a Bicycle Generator BG-16
Cost of Electricity BG-19

HELIODON

Use of the Heliodon to Determine the Direction to Face a Solar Home HL-1
The Effect of Orientation on the Performance of a Solar House or Device HL-4
Shading Factors Affecting the Amount of Available Solar Energy HL-7
Amount of Solar Energy Available: Winter vs Summer HL-10
The Effect of the Solar Arc on Heating HL-13

SOLAR PATHFINDER

Assembly and Use of a Solar Pathfinder SPF-1
Site Analysis for Domestic Solar Water Heating SPF-7
Site Analysis for Active Space Heating SPF-11
Orientation of Solar Cells for Electrical Energy SPF-15

COMPASS

Measuring the Sun's Position CP-1
Comparisons of Solar Heat Gain in Collectors of Differing Exposures CP-5
Site Evaluation for Locating a Solar Heating System CP-8
Absorptive Colors For Solar Collector CP-11
Building Shape Affects the Usage of Solar Energy CP-14

THE ENERGY SOURCEBOOK

INTRODUCTION

Program Design

The Energy Sourcebook project's purpose is development and implementation of a Valley-wide program integrating energy education into existing high school curricula. The Energy Sourcebook is not a textbook, rather it is a collection of learning activities for grades 9-12 designed to supplement methods and materials already in use, with activities adaptable to a variety of high school study areas. All materials are specific to the energy resources in the Tennessee Valley.

Six energy resources are most important in the Valley. Solar energy applications and the electricity produced by hydropower, nuclear and coal-fired generators are significant energy sources, as is conservation. In the future, the Valley will depend even more on energy conservation and the alternative energy sources now being developed. These energy resources are presented in separate sections of the Energy Sourcebook. Each section begins with a brief overview which provides background information, including some historical information, descriptions of current technologies, present environmental concerns relative to the production, and use of that resource in the Valley. The sections are numbered separately and all page numbers include a letter designating the section to which they belong; e.g., the first page of the Hydro unit is designated -H-1-. Following each overview are classroom activities which enhance basic understanding of the particular energy source. Some of the activities include worksheets for student use (e.g., data sheets). These are designated by a border on the page and may be copied for distribution to the students.

The special projects section describes research activities, construction projects, field experiences, and computer programs developed by individual teachers. These projects are detailed so that similar learning activities can be implemented in other Valley schools. Some materials are available upon request.

The final section of the Sourcebook provides activities which utilize special equipment and models. These are available for extended use from TVA's seven district power offices.

A major goal of education today is to teach students not just to remember information, but also to fit that information together with experiences and values in a productive, action-oriented way. Therefore, the Sourcebook's approach is one of inquiry. Research indicates that this approach produces better learning, i.e., better recall, more understanding, and better integration of new material with previous knowledge.

The _Energy Sourcebook_'s underlying conviction is that energy education is vital. Today's students - tomorrow's consumers - will be required to make decisions greatly affecting the quality of their lives. Those energy choices must be based on a sound knowledge of energy. Throughout the _Sourcebook_ it is recognized that all conventional energy resources are in limited supply and that problems exist in producing and using energy. Following are key concepts necessary to this understanding of the energy picture.

* Energy is necessary to the production of goods and services, but its production and use must be such that the quality of our environment is ensured.
* The era of cheap energy is over.
* Energy conservation means consuming less energy and using more efficiently the energy we consume.
* Nonrenewable energy resources must be conserved as the transition to renewable energy is made.
* Cost-effective energy alternatives must be explored, developed, and utilized.
* Our nation's intensive use of foreign supplies of energy resources creates dependence which must be reduced.

A Final Word

There are over 80 energy education activities in the _Energy Sourcebook_. Among them are activities suitable for almost any high school group in the Valley, from ninth grade general science or math to twelfth grade physics or economics. Some are simple and require little background information or equipment. Some are elaborate and could become ongoing projects. Whatever your teaching environment, the _Energy Sourcebook_ can provide activities to help prepare your students make sound energy judgements as consumers in tomorrow's world.

SOLAR ENERGY

OVERVIEW

Almost all of earth's energy originates in the sun. Through photosynthesis, radiant energy is converted to chemical energy which not only supports life but, in the form of fossil fuels, powers our cars and lights our cities. In addition, the heat of the sun drives the wind and powers the water cycle. Capturing solar energy and converting it to a usable form is one of the major technological challenges of our time.

Solar energy has the tremendous advantage of being renewable. It is a source of free fuel for billions of years to come. Solar energy has a great advantage over fossil fuels in that it causes no air pollution. Unlike nuclear power, solar energy produces no dangerous wastes. Sunlight is available everywhere on Earth. As with all energy resources, there are some disadvantages in the use of solar energy. Solar technology often requires a large initial investment. The availability and strength of sunlight differs at various locations, and man has no control over weather factors which affect the use of solar energy. Perhaps the major drawback is that sunlight is not available at night when heating needs are greatest.

Using solar energy is not a new idea. Humans have always used the sun's warmth and light. Civilizations not only made direct use of the sun's energy but also used it indirectly by using wind power in sails and windmills, hydropower technologies like waterwheels, and biomass (plant materials and/or animal waste) fuels.

The sun's energy has played an important role in human history. From early man drying animal pelts in the sunlight to Greeks designing passive solar homes in response to shortages of wood for heating to solar heating in Roman public baths to present-day solar water heaters (e.g., those saving electricity for consumers in the Tennessee Valley)--man's use of the sun's vast supplies of energy has taken many forms and has been of varying relative importance among other energy resources. However, as new ways to conserve energy and new alternative technologies are sought, solar power technologies can only become more important.

There are two basic kinds of solar technology--active and passive. An active solar system is one which captures and transports the energy to be used somewhere else. A solar water heater is an example of an active solar system. The water is heated by the sun, then goes to another area of the house for use. Passive solar systems are heat traps. These are buildings designed to capture the sun's heat. A greenhouse is an example. Passive systems generally do not have moving parts.

There are numerous methods of collecting solar energy for active use. Flat-plate collectors are the most common device for heating water. These are the flat, dark, glass-covered boxes seen on roofs and in backyards.

The box acts as a heat trap. Heated water leaves the collector and is transferred to a storage tank or to a conventional water heater. The heated water can be used for such normal household purposes as bathing. In some systems, the water is used to heat the house and is stored in tanks in the basement until its heat is needed.

Solar (photovoltaic) cells are the electronic devices which convert sunlight directly into electricity. They are in common use in calculators. The wing-like structures on artificial satellites are panels of solar cells. In space, where there are neither clouds nor night, solar cells provide an endless supply of electricity and are very efficient. A solar-powered airplane, the Gossamer Penguin, has been successfully flown in Europe and some solar electric cars have been built.

Although solar energy itself is "free," the cost of arrays of solar cells large enough to provide power for a household is prohibitive, as is the cost of providing such a house with storage batteries. A break-through in the cost-effectiveness of solar cell electrical production would certainly change the world energy situation. At present, small solar cells are available from any scientific or electronic supply house or catalog and may be used for a variety of small-scale uses.

To use the sun's energy for producing large amounts of electricity currently requires a modification of steam generation rather than photovoltaic cells. A solar furnace uses concentrated sunlight to boil water and produce electricity from steam-powered turbo-generators. Heat is produced when a huge array of mirrors on a slope focuses sunlight on a point on a boiler. Solar furnaces are currently producing electricity in France and in Arizona. A tower boiler is a variation of the solar furnace. A tower serves as the focal point for an array of mirrors on level ground. Water is heated to steam within the tower and eventually electricity is produced. These generating apparatuses are most practical for desert areas because of the amount of groundspace they require as well as the availability of maximum amounts of sunlight.

Passive solar technologies trap the sun's heat and employ only the properties of heat energy in its storage, transfer, or use; mechanical devices, do not assist in these processes. Passive solar building design, for example, has features which maximize solar heat gain in winter and minimize it in summer. Orientation of windows, shading devices, and landscaping may all play a part. Special features such as thermal masses (e.g., brick or concrete walls or floors) to absorb heat and release it slowly, greenhouse-like solariums or "sunrooms," and Trombe walls may be included in passive solar design. Trombe walls are hollow, vented exterior walls oriented toward the south which act as solar collectors. Air in them heats, rises, and circulates through the room, drawing cool air into the vents at the bottom of the wall. Passive solar designs are generally considered energy conservation measures, and insulation is an important consideration.

Passive use of solar energy is often on a small scale. Solar ovens are a very small-scale use of solar heat. They are easy to build and use free fuel. Parabolic reflectors are commercially available and are designed to focus the sun's rays on a grill or spit, making it possible to cook meat as well as other foods. If cooking with such ovens is not always practical, the ovens can be used as food driers. Solar energy can be used to prepare some foods without using a solar cooker or dehydrator. "Sun tea" is a popular method of preparing iced tea. The heat of the sun increases the kinetic activity of the water molecules, and tea is brewed.

Our current standard of living requires an inexpensive supply of energy. However, the price of oil and coal as energy resources will increase as supplies dwindle; nuclear power is stymied by regulation and adverse environmental effects; and hydroelectric and wind power are available only in certain areas. The sun is a source of free energy. The principal costs of solar energy lie in the initial investment and required maintenance and are prohibitive to most potential users at this time. Solar energy cannot totally replace conventional sources, but it can help lessen our dependence on nonrenewable fuels (foreign and domestic), while giving us individual independence and more direct control in meeting our energy needs.

THE SUN IN MYTHOLOGY AND HISTORY

USE WITH:
General Science
World History
World Geography
English

TIME:
2 class periods plus library assignment

MATERIALS:
Record: Icarus by Paul Winter Consort
World map outline

Objectives

The student will:
1. Construct a time line.
2. Demonstrate library skills.
3. Draw morals from a myth.
4. Locate cultures on a world map.

Background Information

Daedalus was a famous architect and sculptor in Ancient Greek mythology. According to the myth, he lived in Athens and grew jealous of one of his students, Talos. He killed Talos and fled from Athens to Crete, taking his son, Icarus, with him. In Crete, he built the labyrinth of the Minotaur for King Minos. Daedalus soon fell from favor with the king, and both he and Icarus were imprisoned by Minos. In order to escape, Daedalus built two pairs of wings of wax and feathers. He cautioned Icarus to fly low over the water and not to get too high or the wax would melt. Icarus, filled with the joy of flying, failed to heed his father's warning. Icarus flew too near the sun, and his wings melted. He plunged into the sea and drowned.

Procedure

1. Play recording of Icarus by Paul Winter Consort.
   a. Ask students to describe what the music brings to their minds. (You could have them make a drawing.)
   b. Ask if anyone knows the meaning of the title, Icarus.
   c. Relate the Icarus myth.
   d. Ask students to draw morals from the myth; discuss.

2. Divide the class into four groups. Assign each group one of the early cultures listed below. Ask students to find a solar-related myth or belief belonging to the assigned culture.
   a. Japanese
   b. Aztec/Incas
   c. Egyptians

3. Have students present findings to class at subsequent meeting. Encourage a variety of presentations (skits, illustrations, etc.).

4. Discuss present scientific knowledge about the sun and ask students to describe some current energy technologies.

5. Have each student construct a solar time line based on the information presented.

6. Have students locate each culture discussed in class and each time line entry on the world outline map.

7. Follow with discussion.

Discussion

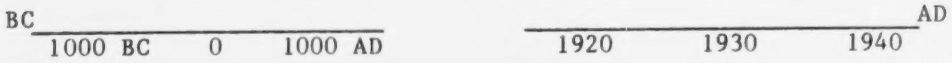
1. Why did so many early cultures have solar myths?

   Man has always developed a mythology to explain things he did not understand. This has been especially true of natural phenomena. Since one natural phenomenon all cultures experience is the rising and setting of the sun, it is quite natural that explanations for this daily occurrence are common to many cultures.

2. What is an appropriate scale (interval) for the time line?

3. Why was an appropriate interval difficult to determine?

   The early pre-historic myths establish one end of the time line and the many recent solar developments establish the other. Because there are many recent developments of significance, the recent end of the time line needs small divisions. One way to deal with this problem is to use a broken time line with two scales, e.g.



4. Why are there so many more late entries on your time line than early ones?

   Discussion should center on the incremental effect of scientific discoveries, i.e., one discovery leading directly to several more. There has been a geometric increase in the amount of information in recent years in most subject areas. Advances in information retrieval systems and data collection mechanisms as well as the increased longevity of the population and improving economic conditions in much of the world have also contributed to the explosion of information.

5. What inferences can be drawn from an examination of the world outline maps?

   Two possible explanations would seem to be that there are large parts of the world that have not contributed to our solar knowledge or that there are areas whose contributions the class has not yet discovered. A hypothesis to explain each of these viewpoints should be developed, and each hypothesis could become the focal point for future library research.

Resource

Paul Winter Consort. Icarus. Epic Records, 1972.

TRACING THE FLOW OF SOLAR ENERGY

USE WITH:
Special Ed. (Science)
General Science
Physical Science
Environmental Science

TIME:
1-2 class periods

MATERIALS:
Worksheets (included)

Objectives

The student will:

1. Trace the flow of solar energy.
2. Associate the First Law of Thermodynamics with the concept of energy transformation.
3. Recognize the relationships between the sun and:
    a. coal
    b. wind power
    c. hydropower
    d. the food chain
4. Identify examples of:
    a. light and heat
    b. potential energy
    c. kinetic energy

Background Information

The energy your brain is using to read this originated in the sun. Your car is powered by energy that came to Earth over 200 million years ago, as is your stereo (if your electricity comes from a coal-fired power plant); but if your power comes from a hydroelectric plant, then the original energy came from the sun only a few months ago. Even sailboats are powered by the sun. Air, warmed by the sun, rises creating wind. Nuclear, tidal and geothermal energy are the only types of energy which originate on Earth.

The First Law of Thermodynamics states that energy can change forms but it cannot be destroyed or created. Green plants change sunlight to chemical (potential) energy by photosynthesis. The great forests of the Coal Age were buried millions of years ago. The coal mined today contains the stored energy of countless ancient plants. This energy is released as heat when coal is burned. In a boiler, heat causes water to vaporize. The steam moving through pipes to a turbine contains kinetic energy. Other terms for kinetic energy are mechanical energy, physical energy, or energy of motion. The turbine turns a generator which produces electricity. The consumer then changes the electricity to sound energy, with a stereo, or mechanical energy, with a blender, or heat. Much of it is used for light, the same form the energy had hundreds of millions of years ago!

There is a loss of energy at each step of the process. Heat is lost to the environment in the boiler. The turbines make noise and friction. The energy we use today is but a fraction of one percent of the light reaching Earth all those years ago.

Gasoline, like coal, is a fossil fuel. The energy associated with it goes through transformations similar to those associated with coal.

The sun provides energy for animals through plants. An animal that eats only plants (an herbivore) has more energy available to it than does a meat-eater (carnivore). Carnivores eat herbivores, but the herbivores have used some of the plant energy they have consumed for metabolism. This energy is lost to the environment as heat. Consequently, there is not as much energy available to meat-eaters.

For example, it takes about 30 pounds of corn to produce one pound of beef. Thirty pounds of corn provide much more energy than does one pound of beef. Because fish are "cold-blooded," it takes only about three pounds of plants to make one pound of edible fish. Fish do not have to use energy to heat their bodies. Both fish and beef provide protein.

The heat of the sun causes air to expand and rise. Cold air rushes in to replace the less dense warm air and wind is created. Modern windmills have blades which turn a driveshaft connected directly to an electrical generator.

The sun's heat also causes water to evaporate. The vapor is transported by wind to cooler areas where it condenses and becomes rain. The rain flows back into the sea. We harness the power of this cycle by building dams and powerhouses. Water is diverted to flow through a turbine which turns a generator.

Procedure

1. Discuss with students the concept of energy transformation and define these terms: light, heat, kinetic energy, potential energy, and electricity.

2. Have the students trace the energy flow beginning with the sun on each of the four worksheets: Power from Coal, Wind Power, Food Chain, and Hydroelectricity.

3. Have the students indicate the form of energy in each step by filling each blank with one of following: light, heat, kinetic energy, potential energy, or electricity.

4. Follow with discussion.

Discussion

1. What changes does energy go through to power an automobile?

   (a) The energy came to Earth in the form of light several hundred million years ago.
   (b) Ancient plants changed the light into potential (chemical) energy.
   (c) The potential energy was stored underground.

(d) Burning the gasoline releases the energy in the form of kinetic energy, which causes the expansion of gases in the cylinder of the engine. The expanding gases force the piston down; the piston rod turn the crankshaft, which turns the driveshaft which turns the axle which turns the wheels--all forms of kinetic energy.
(e) Burning the gasoline also causes heat to be given off.
(f) Some of the energy is given off in the form of noise.

2. How is energy "lost" in an automobile?

The heat and noise given off by the engine do not contribute to the automobile's motion. This is "wasted" energy. Sometimes the gasoline does not burn thoroughly. If the engine needs a tune-up, for example, then energy is lost by incompletely burned gasoline going out the exhaust.

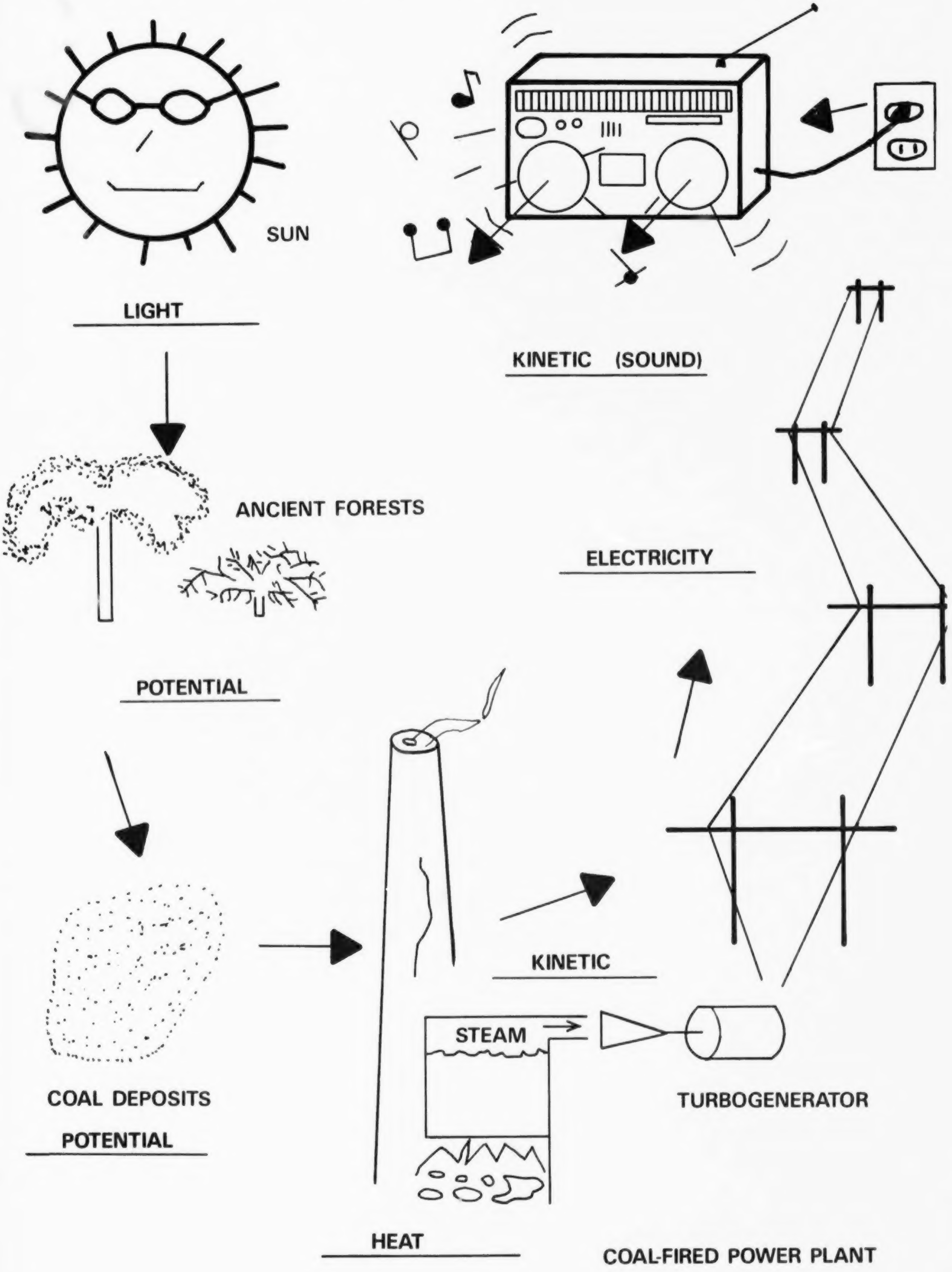
3. How is energy "lost" in the food chain?

The reason that not as much energy is available to carnivores as is to herbivores is that carnivores eat herbivores. The herbivores must use energy to stay alive. Therefore not all the energy a herbivore takes in is available to the meat-eater. Since some of it has been used in metabolism. In birds and mammals, much of this energy is used to maintain the animal's body temperature. Energy is lost to the environment as body heat.

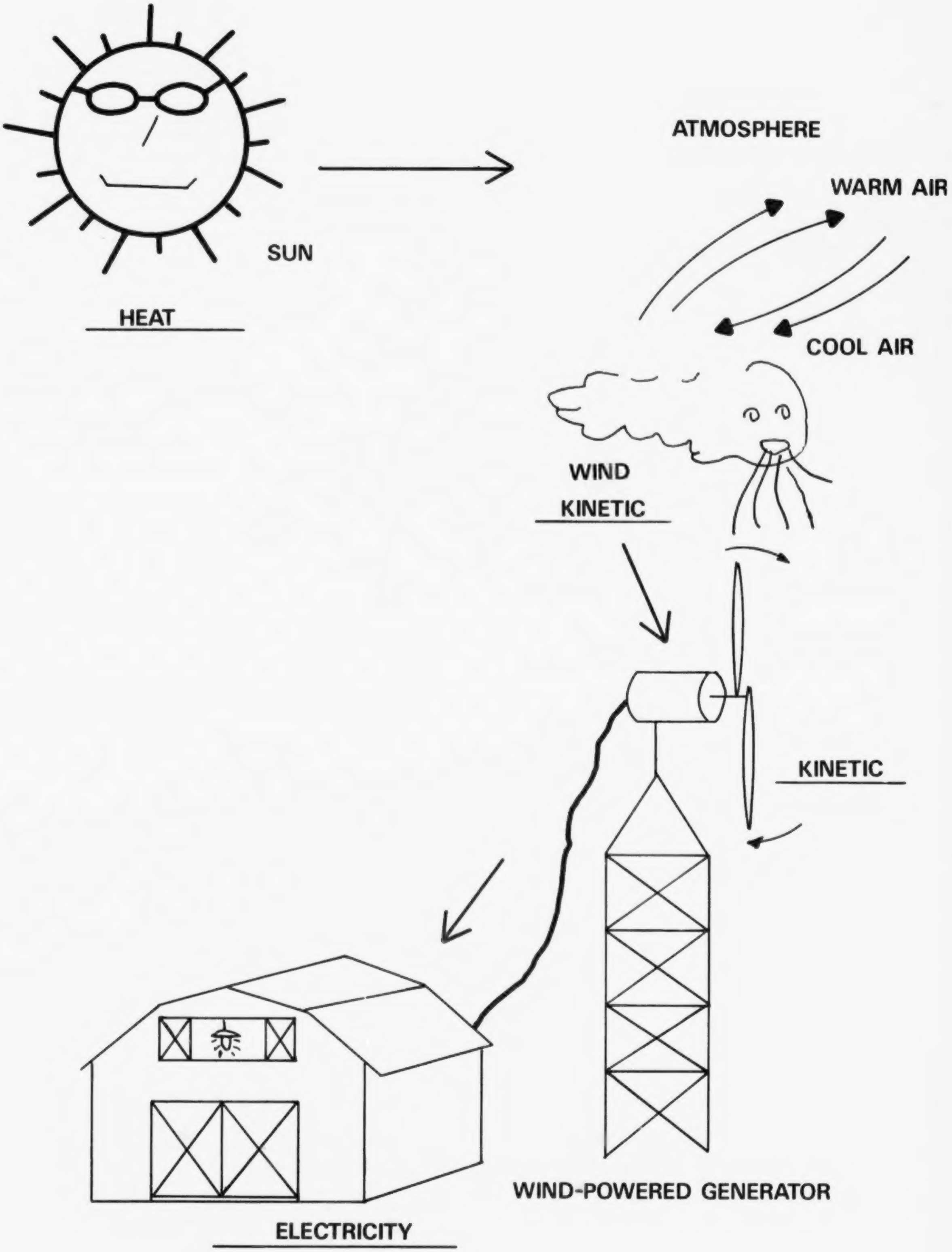
4. Can there ever be an electricity generating system which loses no energy?

No. A 100 percent efficient system is impossible. Friction between moving parts steals energy. The heat loss in a coal-fired power plant is substantial because it is difficult to capture and use this energy.

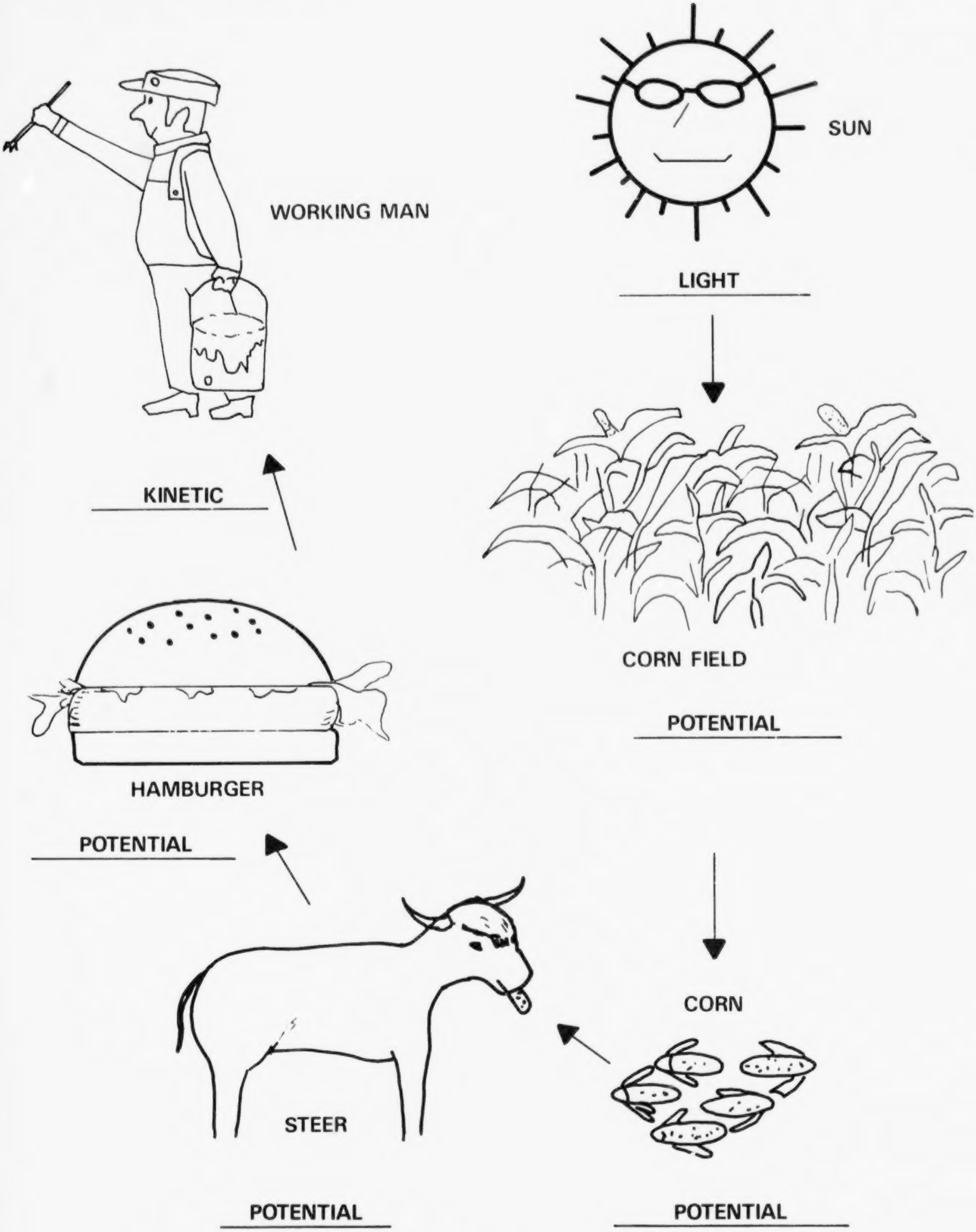
POWER FROM COAL   TEACHER KEY


SUN
LIGHT
ANCIENT FORESTS
POTENTIAL
COAL DEPOSITS
POTENTIAL
HEAT
STEAM
KINETIC
TURBOGENERATOR
COAL-FIRED POWER PLANT
ELECTRICITY
KINETIC (SOUND)

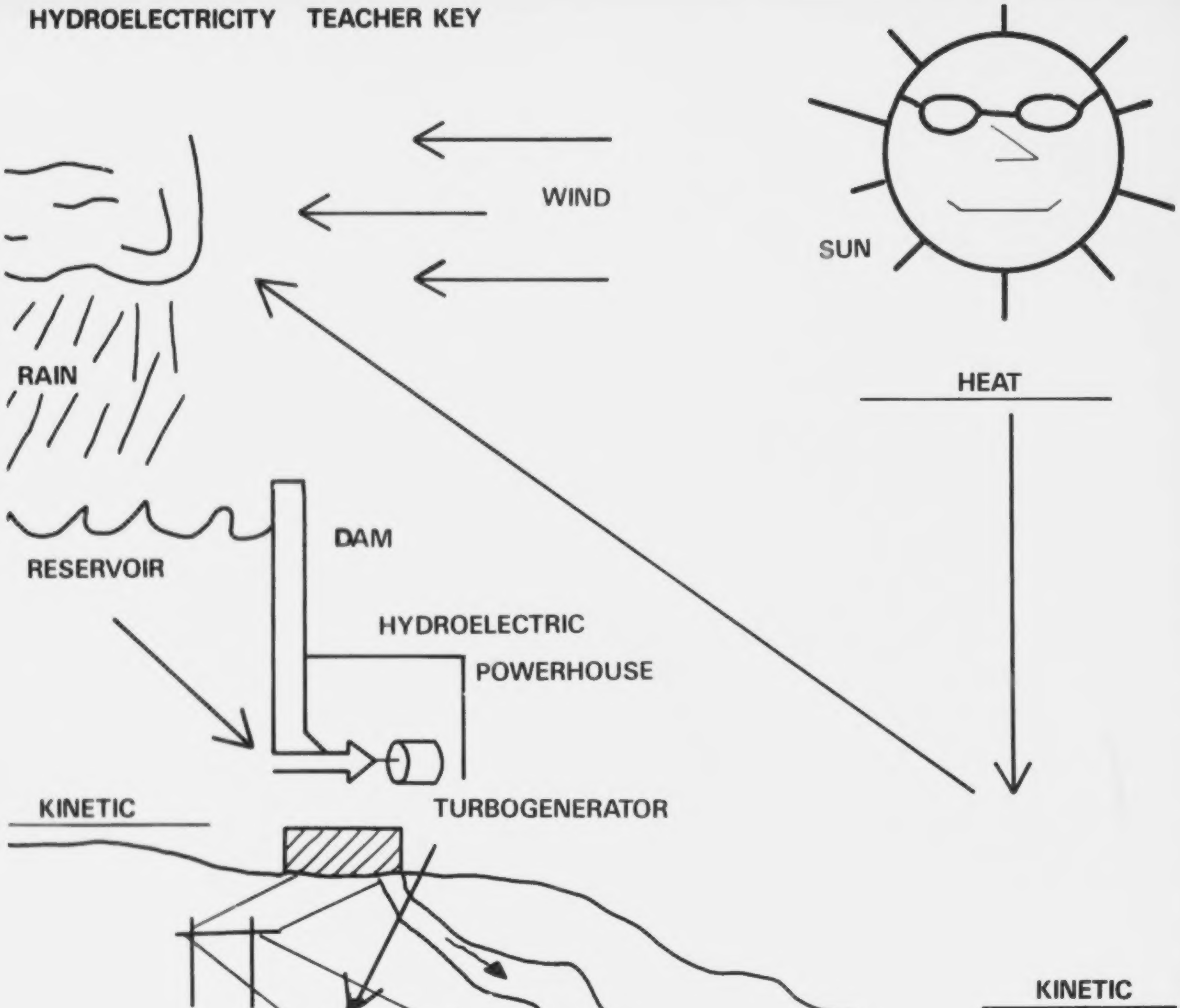
WIND POWER TEACHER KEY


SUN
HEAT
ATMOSPHERE
WARM AIR
COOL AIR
WIND
KINETIC
KINETIC
WIND-POWERED GENERATOR
ELECTRICITY

FOOD CHAIN TEACHER KEY


SUN
LIGHT
CORN FIELD
POTENTIAL
CORN
POTENTIAL
STEER
POTENTIAL
HAMBURGER
POTENTIAL
KINETIC
WORKING MAN

HYDROELECTRICITY TEACHER KEY


SUN
WIND
HEAT
RAIN
RESERVOIR
DAM
HYDROELECTRIC POWERHOUSE
KINETIC
TURBOGENERATOR
KINETIC
EVAPORATION
RIVER
SEA
ELECTRICITY

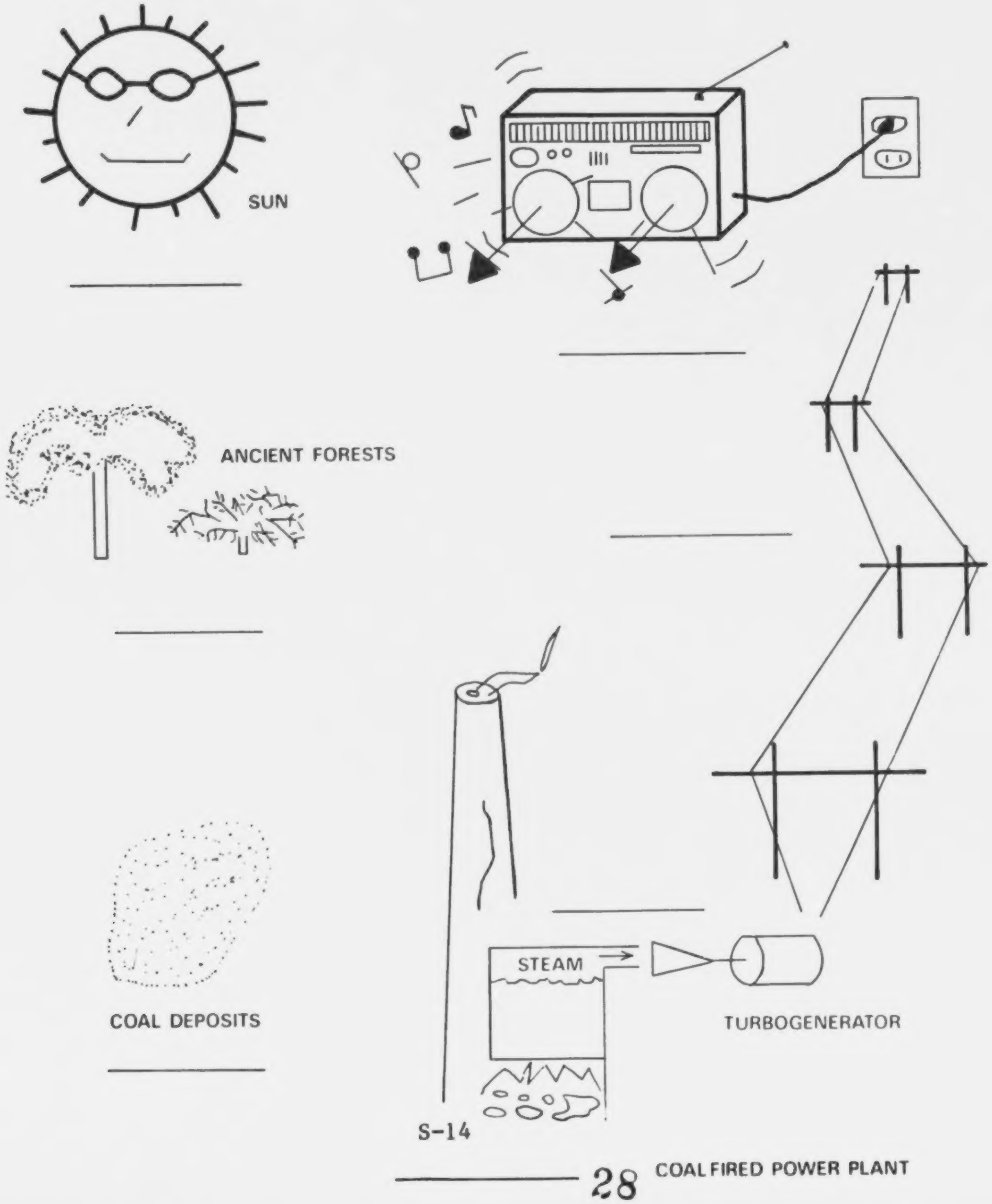
TRACING THE FLOW OF SOLAR ENERGY

Instructions

1. Draw arrows beginning at the sun showing the direction of energy flow to each succeeding step.

2. Indicate the form of energy in each step by filling each blank with one of the following: heat, light, kinetic energy, potential energy, or electricity (a specific type of kinetic energy.

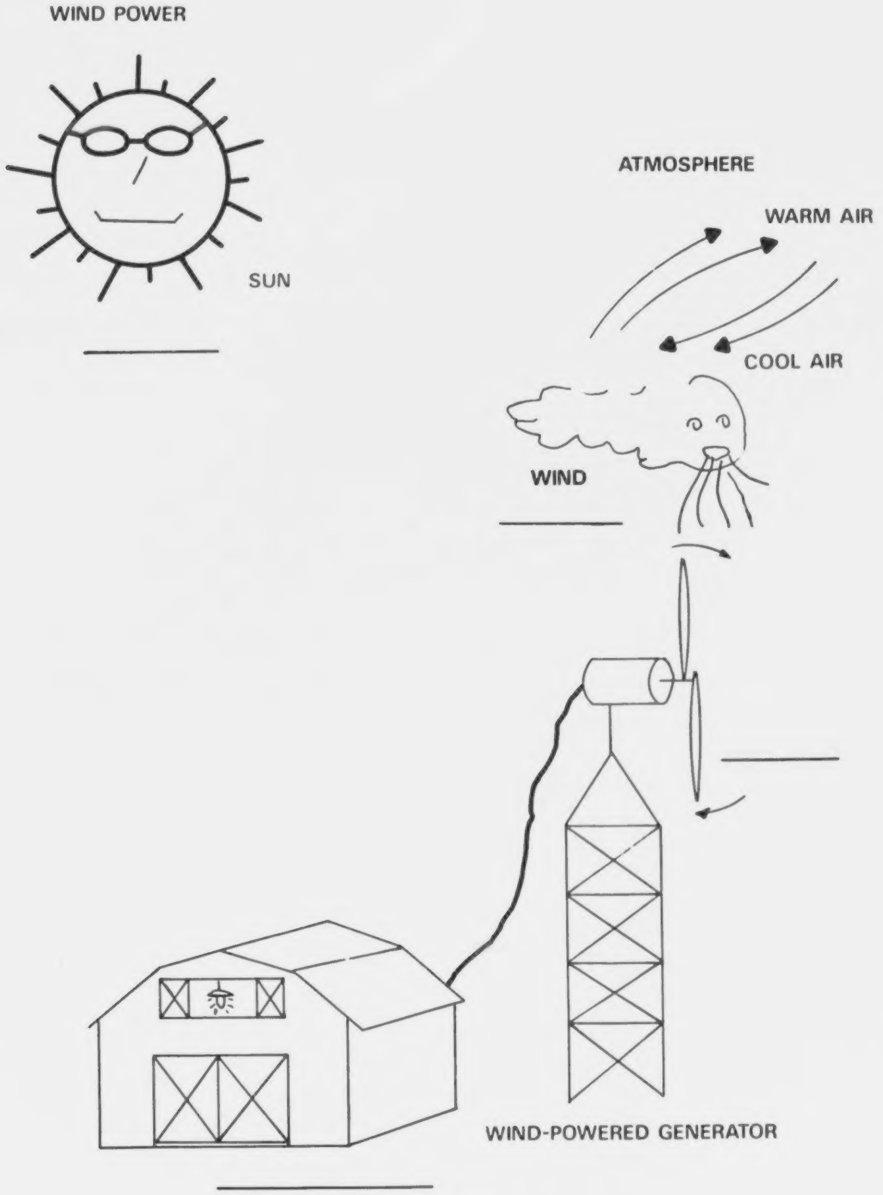
POWER FROM COAL


SUN
ANCIENT FORESTS
COAL DEPOSITS
STEAM
TURBOGENERATOR
COALFIRED POWER PLANT

TRACING THE FLOW OF SOLAR ENERGY

Instructions

1. Draw arrows beginning at the sun showing the direction of energy flow to each succeeding step.
2. Indicate the form of energy in each step by filling each blank with one of the following: heat, light, kinetic energy, potential energy, or electricity (a specific type of kinetic energy).


WIND POWER
SUN
ATMOSPHERE
WARM AIR
COOL AIR
WIND
WIND-POWERED GENERATOR

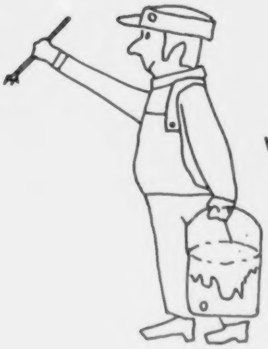
TRACING THE FLOW OF SOLAR ENERGY

Instructions

1. Draw arrows beginning at the sun showing the direction of energy flow to each succeeding step.

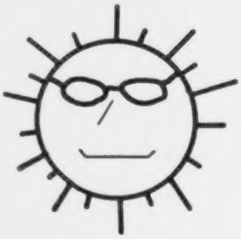
2. Indicate the form of energy in each step by filling each blank with one of the following: heat, light, kinetic energy, potential energy, or electricity (a specific type of kinetic energy).

FOOD CHAIN



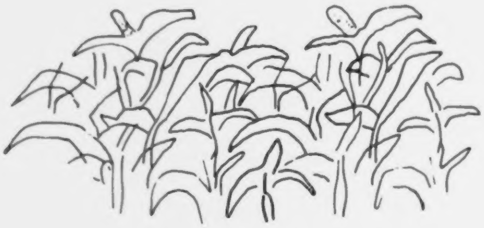
WORKING MAN

____



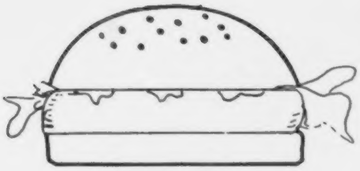
SUN

____



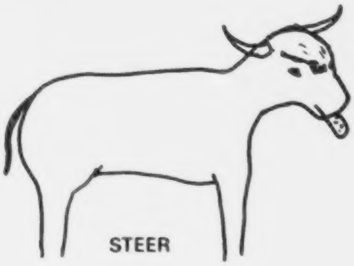
CORN FIELD

____



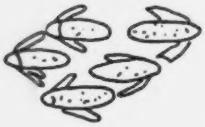
HAMBURGER

____



STEER

____



CORN

____

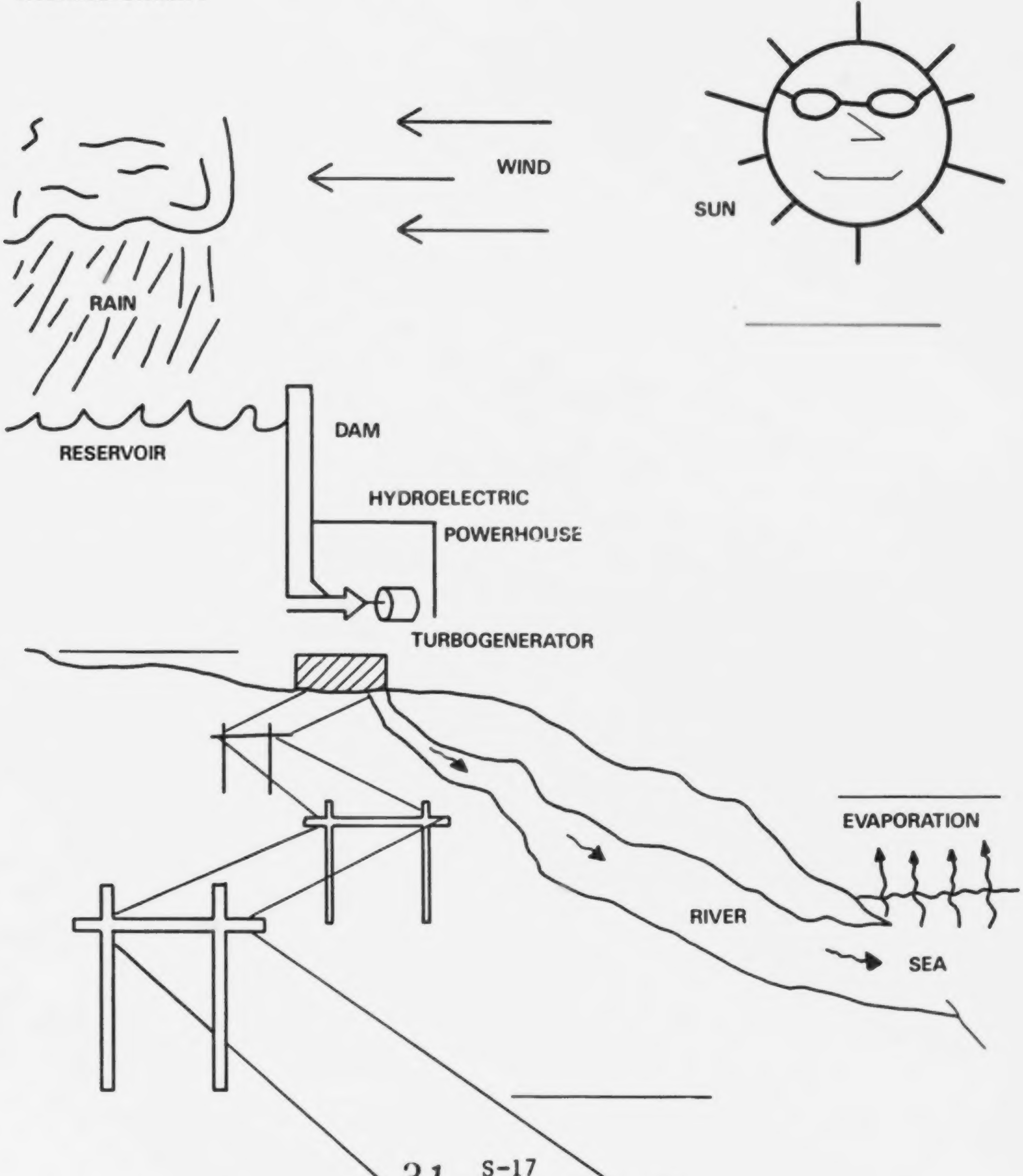
TRACING THE FLOW OF SOLAR ENERGY

Instructions

1. Draw arrows beginning at the sun showing the direction of energy flow to each succeeding step.

2. Indicate the form of energy in each step by filling each blank with one of the following: heat, light, kinetic energy, potential energy, or electricity (a specific type of kinetic energy).

HYDROELECTRICITY


WIND
SUN
RAIN
DAM
RESERVOIR
HYDROELECTRIC
POWERHOUSE
TURBOGENERATOR
EVAPORATION
RIVER
SEA

PURIFYING WATER WITH SUNLIGHT

USE WITH:
Special Ed. (Science)
General Science
Physical Science
Environmental Science
Outdoor Recreation

TIME:
2 class periods

MATERIALS:
Clear plastic wrap
1 drinking glass or beaker
1 large pan or tub
Muddy water
Salt
Small Weight
Water

Objectives

The student will:

1. Build a solar still.
2. Distill water with the sun as the energy source.
3. Make salt water potable using sun as the energy source.

Background Information

When water evaporates, the solids in solution do not. Salt is a good example. The water molecules enter the vapor phase, leaving the Na and Cl ions behind. Once the water is gone, these ions combine to form NaCl. This is because water has a much lower boiling point than salt. If alcohol, which has lower boiling point than water, is mixed with water, the alcohol will evaporate faster, leaving the water behind. But most of the impurities in water are solids with relatively high boiling points, making it possible to purify water with a solar still.

Bacteria will also be left behind as the water evaporates. Evaporation is a process which takes place molecule by molecule; that is, individual water molecules leave the liquid phase independently of each other. Bacteria are millions of times larger than a water molecule and cannot be transported by vapor.

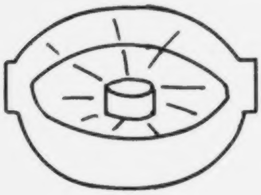
A still is a device which captures vapor and condenses it back into the liquid phase. The condensate is said to be distilled. For evaporation to happen, energy must be added. In the case of a solar still the energy comes from the sun. A solar still is a container of water covered with saran. Saran is the generic name for several brands of plastic food wraps, including Saran Wrap and Handi-Wrap. Any clear, flexible covering will work. A weight in the center of the saran covering causes the covering to become concave. The sunlight passes through the covering and provides the energy for evaporation of the water in the container. The water vapor condenses on the cooler saran covering. Droplets form and slide down the slope created by the weight. At the lowest point, drops form and fall into a beaker which is located directly under the weight.

A solar still can be explained by Kinetic Theory. As the sun heats the water in the pan, the water molecules vibrate with increasing energy. In the liquid phase, molecules are free to move and to collide with one another. The heat energy of the sun is transformed into energy of motion, kinetic energy. Some water molecules near the surface gain enough energy to leave the liquid state and enter the air as vapor. Vapor has greater kinetic energy than does liquid water. When the molecules, now in the vapor phase, strike and adhere to the plastic covering, they lose energy because the plastic covering is slightly colder than the air and vapor within. The loss of energy causes the vapor to re-enter the liquid phase. The water then flows down the plastic covering and drips into the container in the center.

Procedure

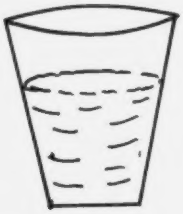
1. Fill a pan or tub to a depth of 5 cm with salt water or with muddy water. Place a drinking glass or small beaker in the center of the pan.

2. Cover the pan with plastic wrap. Tape the edges, forming a good seal. Place a small weight in the center of the plastic above the glass.



3. Place the pan in direct sunlight for several hours. An alternative is to place the pan under a lamp overnight.

4. In the case of salt water, taste the water in the glass. In the case of muddy water, visual observations will show the water to be clean.



Discussion

1. How can you speed up the distillation process?

   Increasing the energy input will speed up the process. This might be accomplished by increasing the surface area of the water by using a larger pan. Perhaps the pan can be painted black. Some light is being reflected away from the water by the covering and it might be possible to find a less reflective covering.

2. How is the process powered?

   The energy for this process originated in the sun. Visible light passed through the plastic wrap. The light energy was changed to heat energy as it struck the water, and the heat was then trapped within the pan by the covering. The covering is transparent to visible light but will not allow infrared light (heat) to pass through as readily. This created a heat trap or greenhouse effect.

3. How could this method be used in the desert where there is no surface water?

   In an emergency or survival situation, drinking water can be distilled from the moisture in the ground. First, a hole is dug a few feet into the ground. The hole is covered and a weight is placed in the center of the covering with a container for catching the condensate directly below. The moisture from the soil evaporates, is trapped, and condenses.

4. Could a solar still be used to clean up toxic wastes in water?

   Any substance with a boiling point higher than that of water will remain behind as the water evaporates. Many waste treatment plants allow the water to evaporate into the atmosphere. The residue is gathered and disposed of in special landfills.

5. What areas of the world might benefit from large-scale solar water purification plants?

   Places lacking fresh water but having access to sea water and sunshine. Examples are California and Israel.

THE INFLUENCE OF COLOR ON HEAT ABSORPTION

USE WITH:
Special Ed. (Science)
General Science
Physical Science
Environmental Science

TIME:
1 class period

MATERIALS:
Metal paint of various colors, including white and black
One aluminum pie pan for each color of paint
Celsius thermometers (three)
Water
Clear plastic wrap
Worksheet (included)

Objectives

The student will:
1. Compare the influence of various colors on heat absorption.
2. Measure the influence of various colors on heat loss.

Background Information

Solar collectors have dark surfaces to maximize heat absorption. One of the fundamental principles of solar technology is that white reflects most light and much heat, while black absorbs most light and much heat. That's why black looks black--it is reflecting almost no light back to the eye. Red absorbs all visible light except red, which it reflects. Yellow surfaces absorb all but yellow, and so on throughout the visible spectrum. Ben Franklin did an exquisitely simple experiment on this subject. He placed a white cloth and a black cloth of the same size and made of the same material on a snow bank in the sun. The snow under the black cloth melted.

Procedure

1. Paint the inside of each pie pan a different color, making sure to paint one white and one black. Leave one unpainted.

2. Add 500 ml of water to each pie pan. Measure and record the temperature of the water in each pie pan.

3. Cover each pie pan with plastic wrap. Place each pan on a book or other insulating material in the direct sunlight for 15 minutes.

4. Measure and record the water temperature in each pan, in data table.

5. This part of the activity is to measure the heat loss of the different colors. Put 500 ml of hot water in each pan. Record the temperature of the water.

6. Place the pans in a place where there is no sunlight. Record the temperature of each pan at 5-minute intervals for 20 minutes, in data table.

Discussion

1. Why is the insulation under the pans important?

   The metal, probably aluminum, in the pans is a very good heat conductor. Heat would be transported by the metal from the water to the ground too quickly without the insulation.

2. Why is the saran covering important?

   The saran covering makes the pans heat traps. The air is not free to circulate. Otherwise, much of the heat collected would be "blown away."

3. Which parts of a house should be painted white or a light color?

   If your house is in the South where air conditioning costs outweigh heating costs, your house will stay cooler with a white roof. Also, south-facing walls should be white. Swimming pools should be painted a light color to keep the water cool in the summer. Green and blue are colors which recreate a mood of coolness. Red, yellow, and orange create an illusion of warmth.

4. Why are solar water heaters black?

   To maximize the efficiency of the solar water heater as a heat trap.

5. Why are electric and gas water heaters white?

   The source of heat in an electric or gas water heater is inside the water heater. It is important to keep the water warm using as little energy as possible. Since white looses heat more slowly than any other color, these types of heaters are white.

DATA TABLES

Procedure 1-4

Color of pan	Initial temp (°C)	Final temp (°C)	Change in temp (°C)

Which color gained the most heat? ____________________

Procedure 5-6

Color of pan	Temperature (°C)					Overall change in temp
	0 min	5 min	10 min	15 min	20 min	

Which color loses heat most quickly? ____________________

MEASURING THE NUMBER OF CALORIES IN SUNLIGHT

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
2 class period

MATERIALS: (groups of 3 students)
Balance (optional)
Celsius thermometer (optional)
Decimeter cube
Graduated cylinder
Grease pen (or soot, black carbon, or black tape
Magnifying glass
Metric rule
Test tube rack
Test tubes (3)
Watch or timer
Worksheets (included)

Objectives

The student will:
1. Define calorie.
2. Determine the amount of heat available from the sun in his/her area.
3. Determine the most efficient method of capturing heat using the materials available.
4. Define the solar constant.
5. Offer several hypotheses to explain discrepancies between data collected and the solar constant.

Background Information

The Calorie

A calorie is the unit of heat required to raise the temperature of 1 gram of water by 1°C. The calorie differs from the Calorie (always written with a capital C) used by dieters. One thousand calories equals one Calorie. A 500 Calorie banana split has 500,000 calories, enough energy to bring 5 liters of freezing water (0°C) to the boiling point (100°C).

Examples

1. How many calories are needed to raise 1 gram of water from 20°C to 30°C?
   Answer: 10 calories.

2. How many calories are needed to raise 10 grams of water from 1°C to 2°C?
   Answer: 10 calories.

3. How many calories are need to raise 5 grams of water from 5°C to 11°C?
   Answer: 30 calories.

The Gram

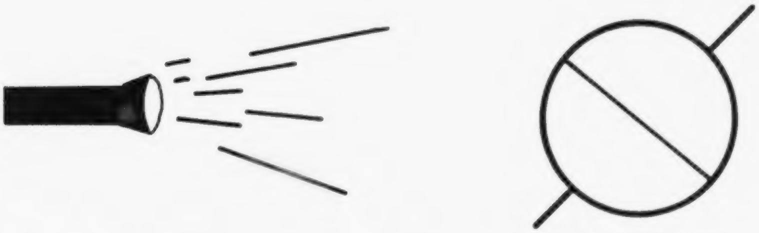
A gram is defined as the mass of one cm^3 of water at 4°C. Since a liter is defined as a unit of volume 10 cm by 10 cm by 10 cm, or 1000 cm^3, one cm_3 is equal to one milliliter (ml). For the purposes of this experiment, a ml of water at any temperature has a mass of 1 gram.

A decimeter cube is a visual aid which will help students understand these relationships. Commercially available decimeter cubes indicate these relationships on the surfaces of the cube. Transferring water from the cube to a graduated cylinder will help learners visualize this concept. Determine the mass of the water to show that a cm^3, a milliliter, and a gram of water are equal.

The Solar Constant

The solar constant (1.94 calories per cm^2 per minute) is the average amount of heat reaching Earth from the sun. Higher latitudes, where the sun's rays strike the surface of Earth at more oblique angles, receive less heat than the tropics. A globe and a flashlight can be used in a darkened room to illustrate how the intensity of sunlight By comparing experimental data to the solar constant, the efficiency

WINTER IN NORTHERN HEMISPHERE



By comparing experimental data to the solar constant, the efficiency can be determined. Other factors affecting efficiency are: atmospheric conditions, the angle of the solar collector to the sun, the month, and the time of day.

The purpose of this activity is to determine how much radiant heat from the sun reaches one cm^2 on Earth per minute. There are variables in this activity that are not well controlled. The reason for using clear, blackened and half-blackened test tubes is to determine the effect of manipulating variables on the outcome of the activity. This adds to the experimental nature of the activity. There will probably be discrepancies in the data collected by students doing this experiment. Encourage students to identify variables that were not held constant.

You should understand the rationale behind each step in the data table. If you would like an added challenge, develop your own data table instead of using the one furnished for this activity.

Procedure

Tell the students they are charged with determining the most efficient method of capturing heat, using the materials available. The illustrations provided in this section may prove useful to them, but give them the option of altering the design of the experiment and designing their own data table. Just make sure their design addresses the purpose of the experiment, which is to determine how much radiant heat from the sun reaches one cm^2 on Earth per minute.

Have the students:

Construct A Hypothesis for Their Experiment

Describe the Procedure for Their Experiment (Use a separate sheet.)

Have their procedure approved by you before continuing.

Collect Data and Describe the Results (Use a separate sheet.)

Parameters and Notes

1. The surface area exposed to sunlight is the same as the area of the lens. Measure the radius of the lens and apply the equation $A = \pi r^2$ (A = area, $\pi = 3.14$, r = radius). Use cm^2 as the unit to measure area.
2. Use 10 ml of water per test tube. Distilled water is preferred if available.
3. Record all temperatures in °Celsius.
4. The light falling on the lens is concentrated at the focal point. Hold the lens perpendicular to the incoming rays. Place the test tube so that the water will be at the focal point.
5. Each trial run of the experiment should last 5 minutes.

Discussion

1. Why does your data differ from the solar constant?

   You may attain an efficiency greater than 100%, because the solar constant is an average taken from all latitudes extending from pole to pole. The solar constant is a yearly average. Less than 100% efficiency may be due to high latitude or time of year. The glass of the test tube reflects light and heat. Heat may have been lost to the air. Never rule out experimental error due to an unsteady hand or poor data collecting techniques.

2. What can be done to increase the amount of heat collected?

The test tubes could be insulated in some way. A larger lens or a parabolic reflector might be used.

3. Using the data in line 1 of the data table, find the number of calories available in 3 m^2 (the area of a small flat-plate collector).

A flat-plate collector is the most common type of solar water heating system used in homes. It consists of a low rectangular box covered with glass. The box is well-insulated and is painted black. Cold water enters one end and is circulated through a serpentine tube exposed to the sun. See the sketch in the activity "Making a Flat-Plate Collector." There are 30,000 cm^2 in 3 m^2. Multiply the data on line 1 of the data table by 30,000.

4. Why doesn't the Earth overheat?

Heat absorbed by Earth's oceans is radiated into space during the night. Earth's 24-hour rotation period is perfect for maintaining a temperature suitable for a variety of life.

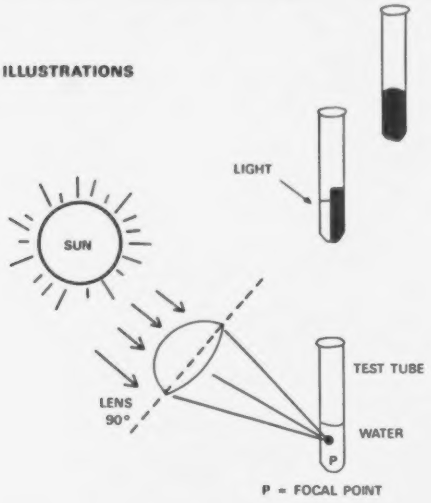
5. How does the time of day affect the availability of solar heat?

At noon, when the sun is closest to us, its rays are most nearly perpendicular to our area on Earth and must pass through less atmosphere than at any other time of the day. In the morning and afternoon, however, the rays strike Earth's surface more obliquely and must pass through more atmosphere than at noon. Heat is absorbed by the atmosphere.

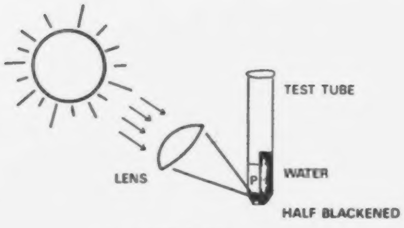
DATA TABLE

	I TRIAL			II TRIAL			III TRIAL		
	1	2	3	1	2	3	1	2	3
A. Radius (r) of lens cm									
B. Area (A) of lens cm^2, $A = r^2$									
C. Water, ml									
D. Initial temperature, °C									
E. Final temperature, °C									
F. Change in temperature, °C (E-D)									
G. Time, minutes									
H. calories (F x C)									
I. calories/cm^2/ minutes (H/B/G)									
J. Solar constant 1.94 ca./cm°/min									
K. Percent efficiency compare to solar constant (I/J x 100)									

SAMPLE ILLUSTRATIONS


LIGHT
SUN
LENS
90°
TEST TUBE
WATER
P

P = FOCAL POINT


TEST TUBE
LENS
P
WATER
HALF BLACKENED

P = FOCAL POINT

MAKING A FLAT-PLATE COLLECTOR

USE WITH:
Industrial Arts
Environmental Science

TIME:
4-6 class periods

MATERIALS:
Caulk, 1 tube
Garden hose, 50 feet
Lumber:
  (2) 2" x 6" x 8'
  (1) 2" x 6" x 10'
  (1) 3' x 4' x 3/8" plywood
Plastic sheet, clear, 5'6" x 8'6"
Styrofoam sheet, (1) 5'8'
Nails: (8) 16 penny
  (40) 8 penny
Tacks or staples (75)

Objectives

The student will:

1. Construct a flat-plate solar collector.
2. Explain how to use a flat-plate collector with a conventional water heater.
3. Describe the energy-saving advantages of a flat-plate collector.

Background Information

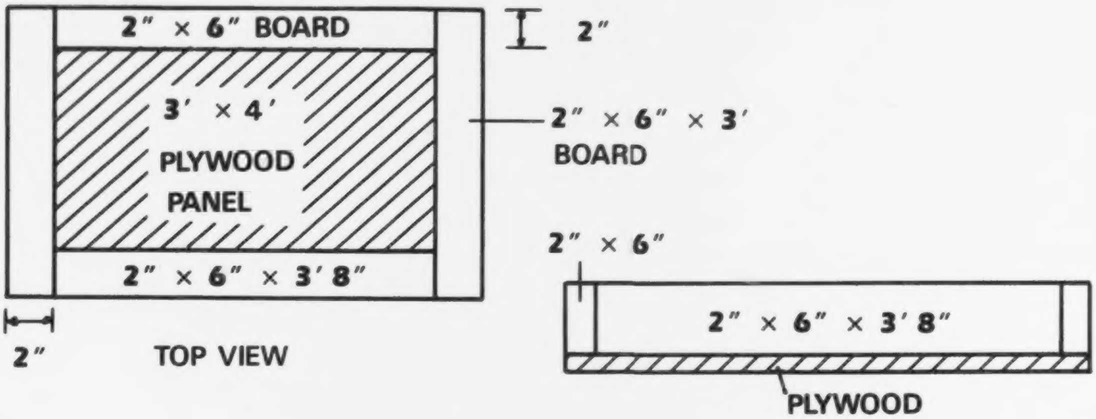
A flat-plate collector pre-heats water before it enters the conventional water heater. For example, if your tap water temperature is 50°F and your hot water is 120°F, then your electric or gas water heater must further heat the water before it leaves the water heater. If the sun heats your water to 85°F, then your water heater has only to heat the water another 35°F. By using the free energy of the sun, you have cut your water heating energy needs in half. Substantial savings in your power bill can be realized.

A storage tank between the solar collector and the conventional water heater will reduce the recovery time of the system. The volumn of water pre-heated by the solar collector is limited to the size of the solar collector. A storage tank increases the amount of pre-heated water available to the conventional water heater.

When building a solar collector, do everything possible to maximize the collector's efficiency as a heat trap. Seal all cracks and air leaks. Paint the interior flat black. Insulate thoroughly. Be sure to insulate the pipe carrying the warm water away from the collector. Place the collector facing south in a place with no shade. The angle of the collector depends on the month. On the average, the sun is at an angle equal to your latitude. In the summer the sun is more nearly overhead, and in the winter it is lower on the horizon. See the activity "Improving the Efficiency of Solar Collectors" for more information on this topic.

Procedures

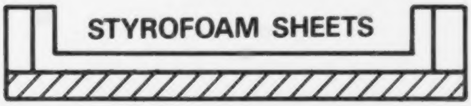
1. Construct a box to the following specifications. Caulk all


2" × 6" BOARD
2"
3' × 4'
PLYWOOD
PANEL
2" × 6" × 3'
BOARD
2" × 6" × 3' 8"
2"
2" × 6"
2" × 6" × 3' 8"
PLYWOOD

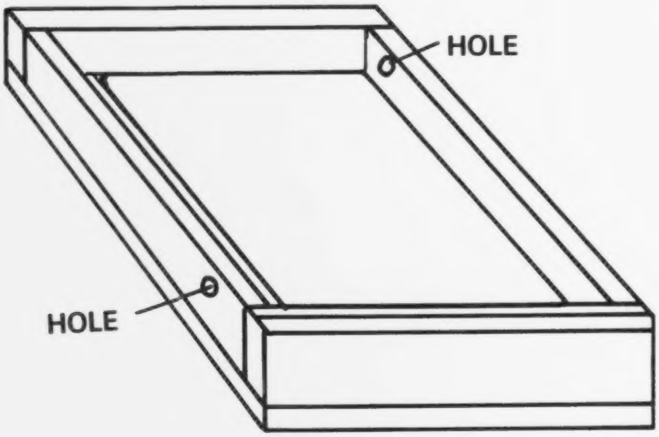
TOP VIEW

SIDE VIEW

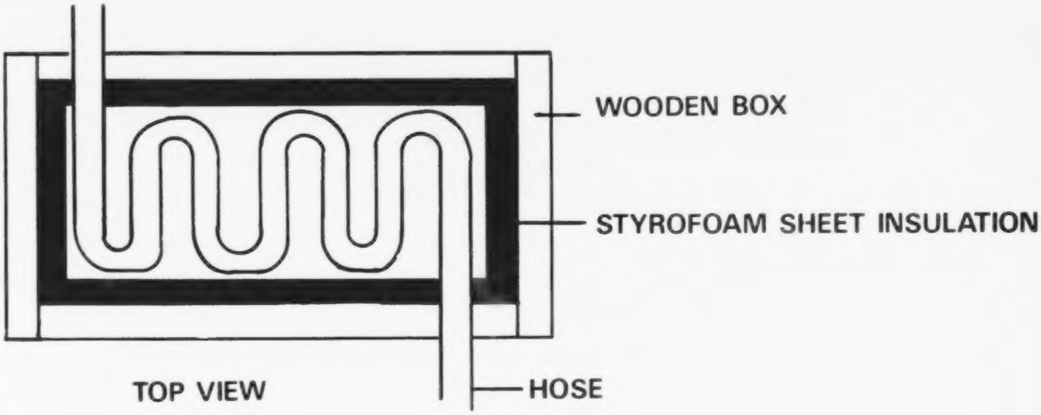
2. Insulate the box with styrofoam sheets or other available material. (Fiberglass insulation loses its insulating value when wet.)


STYROFOAM SHEETS

CUT AWAY VIEW



3. Make holes for the entrance and exit of the hose. Insert hose and arrange as shown in the following diagram.

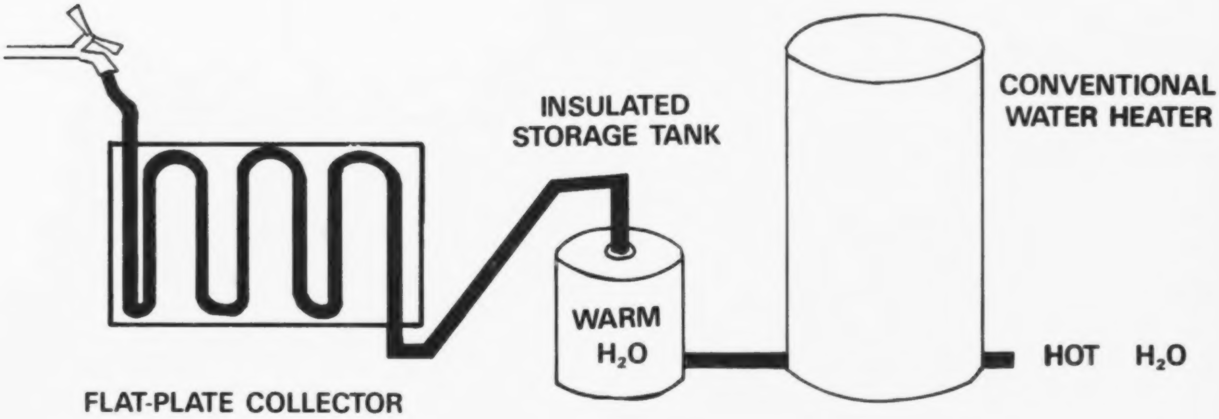

WOODEN BOX
STYROFOAM SHEET INSULATION
TOP VIEW
HOSE

4. Fasten the hose into the box. Caulk all openings.

5. Paint the interior of the box, including the insulation and hose, a flat black. CAUTION: Certain spray paints react with styrofoam. Try your paint on a scrap piece of styrofoam first.

6. Cover and seal the collector with transparent plastic, plexiglass, or glass.

7. Connect one end of the hose to a water outlet and the other end to a storage tank or directly to a conventional water heater. As hot water is drawn from the water heater, the collector will refill automatically.


INSULATED STORAGE TANK
CONVENTIONAL WATER HEATER
WARM H_2O
HOT H_2O
FLAT-PLATE COLLECTOR

Discussion

1. What type of material would be more efficient than a garden hose for the tubing?

   Copper tubing might work better for two reasons. First, copper is a better heat conductor than most types of tubing. Less energy is used heating the tubing, so more heat is available for heating the water. Second, copper tubing has a smaller diameter, so the heat is applied to a smaller amount of water, making the water hotter than it would be in a larger diameter tube or hose. However, copper tubing is expensive and requires special tools.

2. How does the flat-plate collector refill automatically?

   When the hot water tap is opened, the water in the conventional water heater flows out of the faucet. This lowers the water pressure in the conventional water heater. Water in the flat-plate collector, which is under pressure, is then forced into the water heater. This in turn lowers the pressure in the collector and water is forced into the collector, refilling it.

3. What can be done to increase the day-to-day efficiency of the collector?

   Since the sun appears to move across the sky, a rigidly mounted collector would be normal to the incident radiation for only a moment each day. A device to rotate the collector, so that the collector tracks the sun, would greatly increase efficiency. Such devices are expensive and consume energy. Sun is at a different height or angle each day. In the Northern Hemisphere, the sun is at its lowest angle on December 22, the highest on June 21, and it is at an average angle on March 22 and September 21. It is practical to change the angle of the collector each month according to the average height of the sun for that month. (See the activity "Improving the Efficiency of Solar Collectors".)

4. What businesses might benefit from solar water heating?

   Any business which needs large amounts of hot water. Examples are laundromats, car washes, restaurants (for washing dishes), paper mills, motels, spas, and health clubs.

5. What are the environmental benefits of solar water heating?

   With solar water heating, there is no air pollution. The sun is a renewable resource, unlike coal, which is used to generate electricity, or natural gas, which is used in a gas water heater. By using solar water heating, you are using less electricity. This in turn decreases the amount of environmental problems associated with power generation, such as air pollution, hazardous waste, thermal pollution, and acid rain.

6. How does a flat-plate collector save the home owner money? By pre-heating the water with energy provided for at no cost. If the cold water coming into your house is 50°F, your conventional water heater must increase the water temperature by 70o to get the water to 120°. However, if the sun pre-heats the water to 85°, your electric or gas water heater has to increase the temperature by only 35°. This cuts your electricity or gas usage for water heating in half.

7. If you have a flat-plate collector, why does it make sense to bathe and do your laundry in the daytime?

   The major drawback of any solar device is that it has no energy source at night. If you do a load of clothes in hot water after dark, the water going into your conventional water heater will not have been pre-heated.

IMPROVING THE EFFICIENCY OF SOLAR COLLECTORS

USE WITH:
Astronomy
Earth Science
Environmental Science
Industrial Arts

TIME:
2 class periods

MATERIALS:
Drinking straw (1)
Scotch tape
Protractor (1)
String 6"
Weight (small nut)
Map showing latitude of your location

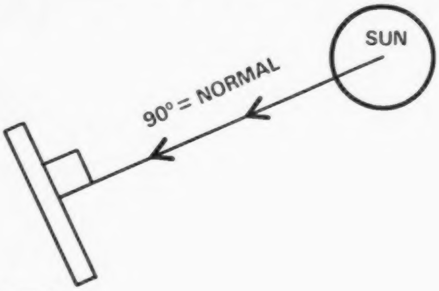
Objectives

The student will:

1. Explain the relationships between latitude, the declination of the sun, and Polaris.
2. Define equinox and solstice.
3. Construct a sextant and/or determine latitude.

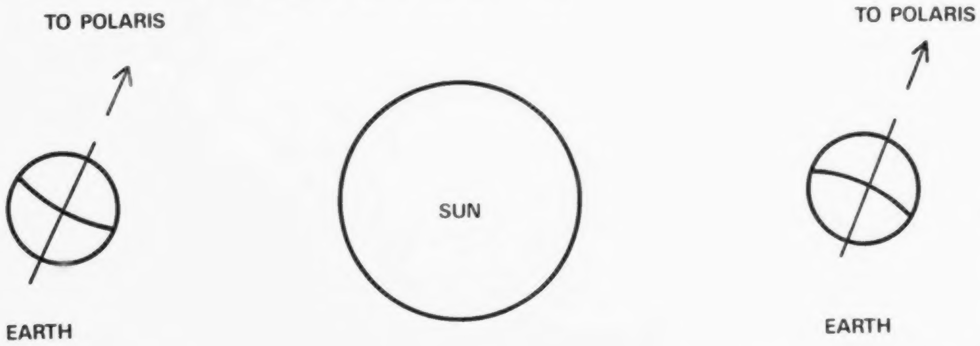
Background Information

For maximum efficiency, a solar collector must be perpendicular (normal) to the incoming (incident) rays of the sun.



FLAT-PLATE COLLECTOR

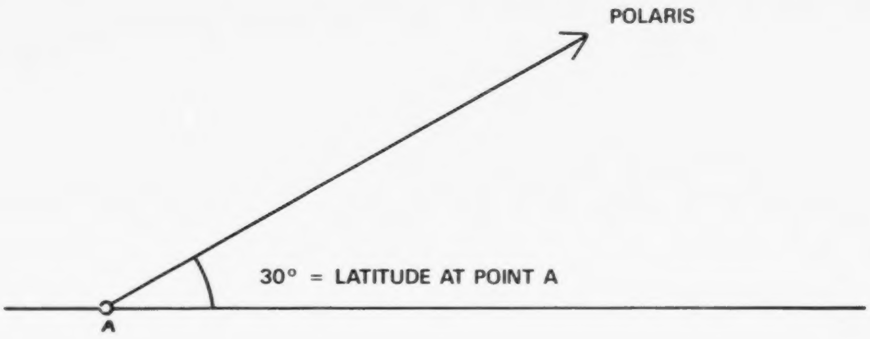
As the earth moves in its orbit, Earth's axis always points to the same point in space. The North Pole always points towards Polaris, the North Star. There is no southern pole star. In summer, the Northern Hemisphere is tilted toward the sun, while in winter the South Pole tilts toward the sun. To us, the sun appears lower to the horizon in winter and higher in summer.



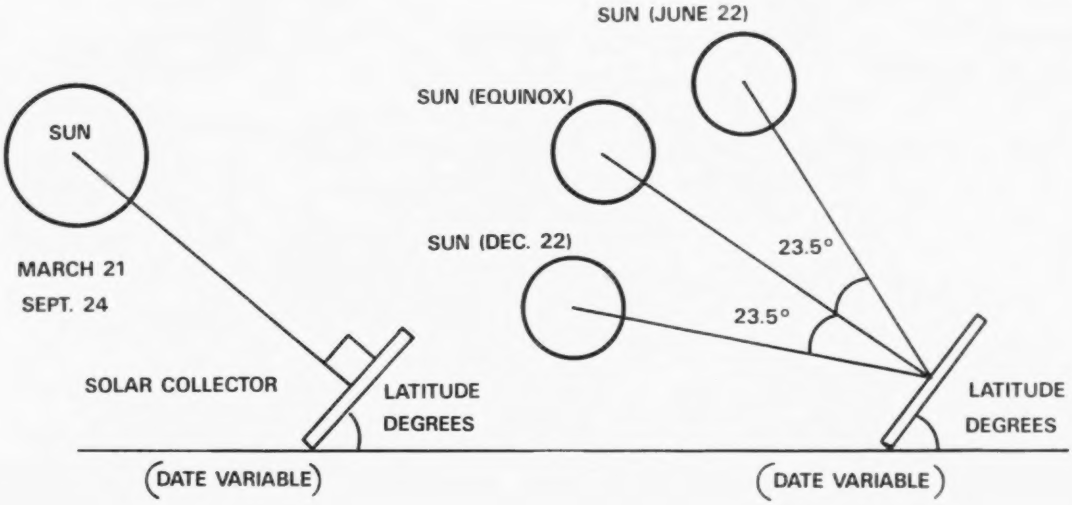
SUMMER IN NORTHERN HEMISPHERE

WINTER IN NORTHERN HEMISPHERE

The Tropic of Cancer is latitude 23.5° North. The Tropic of Capricorn is 23.5° South. Latitude is equal to the number of degrees that Polaris appears above the horizon at a given location. At the North Pole, Polaris is directly overhead. The latitude is 90° North. At the Equator, Polaris is on the horizon, with the latitude 0°. A sextant is a device for determining the latitude by sighting the North Star.


POLARIS
30° = LATITUDE AT POINT A
A

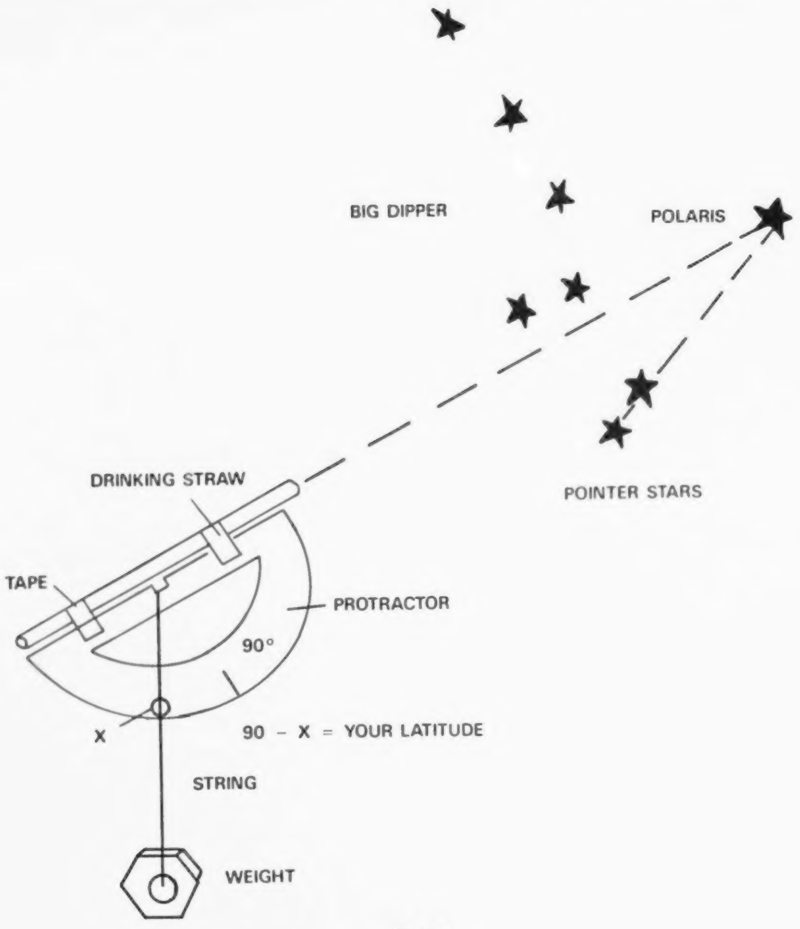
If you set your solar collector at an angle equal to your latitude, then the collector will be exactly normal to the sun's rays during the equinoxes. Three months later, the sun will appear to have moved 23.5° in the sky as it is over one of the tropics on each solstice. Your solar collector will not work as efficiently during solstice because the rays are striking at a somewhat oblique angle. To maximize efficiency, your solar collector needs to be adjustable.


SUN
MARCH 21
SEPT. 24
SOLAR COLLECTOR
LATITUDE
DEGREES
(DATE VARIABLE)
SUN (JUNE 22)
SUN (EQUINOX)
SUN (DEC. 22)
23.5°
23.5°
LATITUDE
DEGREES
(DATE VARIABLE)

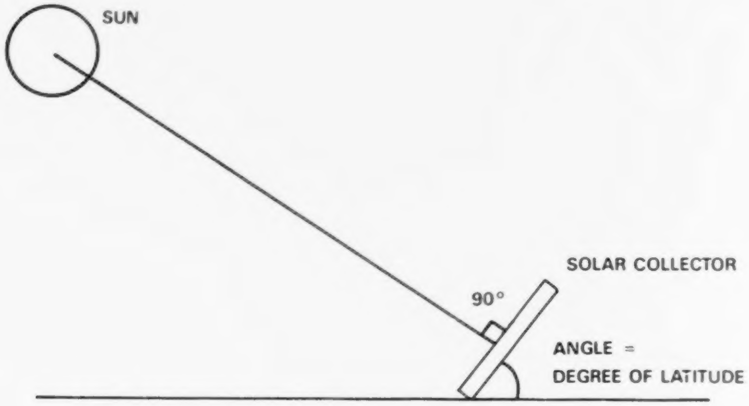
Twice a year the sun is directly over the equator. On these days the length of the day is exactly equal to the length of night, hence the term equinox. The vernal equinox is March 20 and the autumal equinox is September 22. The longest day of the year is when the sun is at its highest point above the horizon. Summer solstice is June 21 and marks the first day of summer. The sun is at its lowest angle on winter solstice, December 21, the first day of winter. During summer solstice in the Northern Hemisphere, the sun is directly overhead at the Tropic of Cancer. It is directly over the Tropic of Capricorn at winter solstice. The dates of the equinoxes and solstices vary from year to year because our year is actually 365.25 days.

Procedure

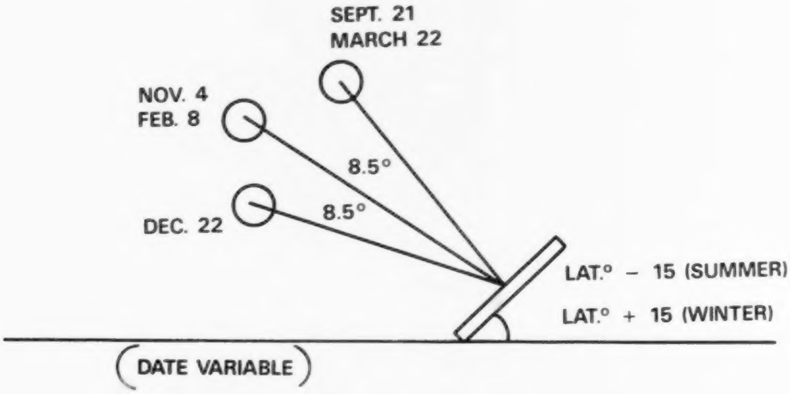
1. Determine your latitude. Either find your location on a map showing latitude or make a sextant. To make a sextant, tie a weight on a string. Tie the other end of the string to the hole in a protractor. Tape a drinking straw to the straight edge of the protractor. Sight Polaris through the straw. To find Polaris, first find the Big Dipper (Ursa Major); the two stars at the end of dipper point to Polaris. Note the degree of elevation indicated by the string on the protractor.



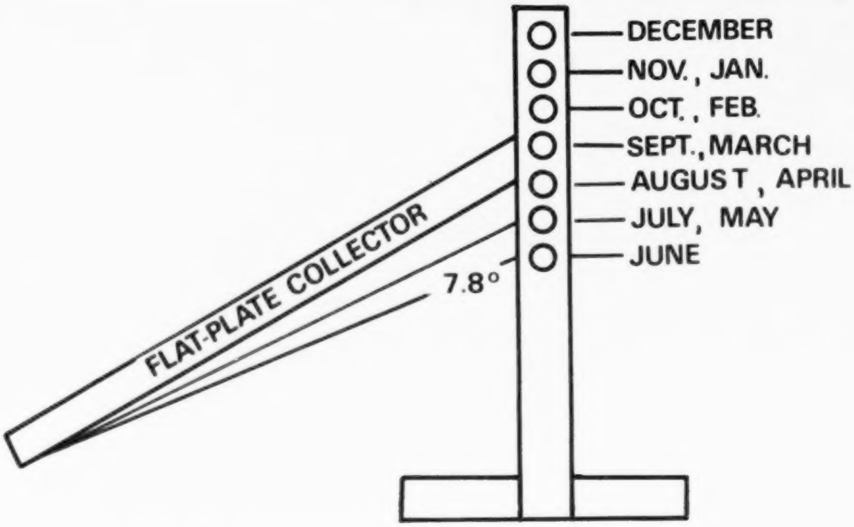
2. Using a compass, face your collector directly south. Tilt the collector at an angle equal to your latitude. Now your collector will be directly facing the sun twice a year, on the equinoxes. But on the average, it will be in line with the sun throughout the year.


SUN
SOLAR COLLECTOR
90°
ANGLE =
DEGREE OF LATITUDE

3. In the winter, the sun is lower in the sky, and you need more heat. You need to tilt your collector at a more efficient angle. It has been determined that increasing the tilt by 15° is the best single adjustment you can make for the winter months. This puts the collector normal to the sun on about November 4 and again on about February 8.


SEPT. 21
MARCH 22
NOV. 4
FEB. 8
8.5°
8.5°
DEC. 22
LAT.° – 15 (SUMMER)
LAT.° + 15 (WINTER)
DATE VARIABLE

4. For greater efficiency, you can make monthly adjustments. The sun's position changes by about 7.8° per month. Thus seven settings on your adjustable collector legs will give you maximum efficiency throughout the year.



Discussion

1. How can the principles of collector angle be applied to the roofs of homes?

   Because most flat-plate collectors are mounted on roofs, modern houses should be built with one roof facing south. Furthermore, the angle of the roof should be equal to or slightly greater than the degree of latitude. It should be greater than the degree of latitude because water heating needs are greater in the winter.

2. When using an adjustable collector like the one described in procedure 4, on which day of the month should you make the monthly adjustment?

   Set your collector on the 7th day of each month. The equinoxes and solstices occur on about the 22nd day of the month. Your solar collector will be exactly normal to the incident rays on about the 22nd, and making adjustments on the 7th will allow 2 weeks before and 2 weeks after the 22nd for solar heat collection at near optimum conditions.

3. What is the advantage of having a system with only two adjustments such as the one described in procedure 3?

   You only have to service your collector twice a year, on September 22 and again on March 22.

Resources

Magnoli, M.A., L.S. Douglass, and D.M. Ellis. Exploring Earth and Space. River Forest, IL; Laidlaw Brothers, 1980. Page 257.

TESTING THE ELECTRICAL OUTPUT OF SOLAR CELLS*

USE WITH:
Physics
Physical Science

TIME:
2 class periods

MATERIALS
- Four 2.5 x 2 cm silicon solar cells
- 2 feet thin-gauge wire (26 gauge or thinner)
- 8 small alligator clips (4 red, 4 black)
- Voltmeter
- Corrugated cardboard
- Soldering iron and solder
- Masking tape
- Marking pens
- Worksheet (included)

Objective

The student will:

1. Measure the electrical output of photovoltaic cells in both parallel and series arrangements and in varying weather conditions.

Background Information

Electricity is the flow of the charged particles through wires. These particles gain energy from a source such as a battery, a generator, or a solar cell, and transfer this energy to a load, such as a light bulb, a motor, or an appliance. The particles then return to the source to complete the cycle. Volts are units that measure the electromotive force given to the electrons in the source.

You can compare the flow of electricity with the flow of water through a pipe. Electric current is the flow of electrons through a wire and is measured in units called amperes (A). Water flowing through a pipe is usually measured in gallons per second. Adding a pump to the water system adds pressure which can push the water faster. The "pressure" in an electrical system comes from an increase in voltage. When water under pressure turns a water wheel, work is done (the wheel turns) and the water loses its pressure. Electric current loses its energy when it goes to a load and does work.

Procedure

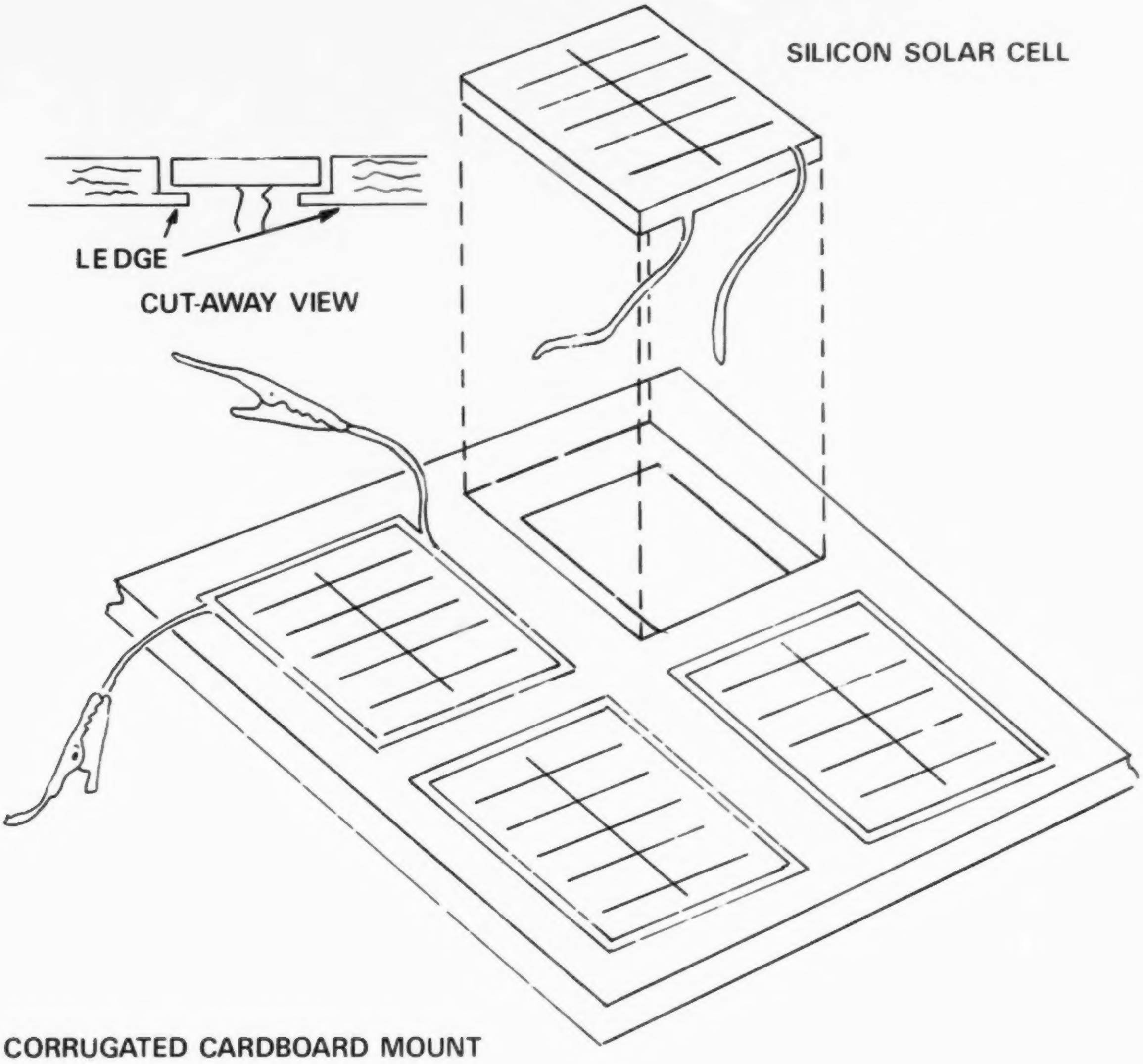
1. Prepare the cells. Since silicon solar cells are fragile, handle them carefully to prevent breaking. Use a small soldering iron (less than 50 watts) and carefully solder a 3-inch piece of thin wire to the negative and positive (location) of each cell. The front of the cell is negative and the back is positive.

---

*This activity is adapted from: Davis and Tiller. Refer to resource listing at the end of the activity.

2. Attach a red alligator clip to the positive lead wire and a black clip to the negative wire on each cell. These leads will enable you to connect the cells in different ways.

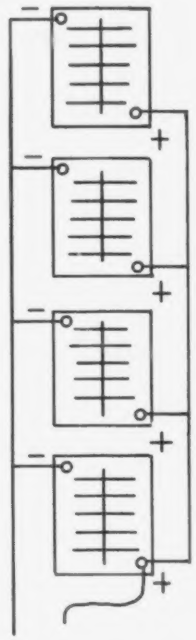
3. Make a mount for the 4 cells using a piece of heavy, double-faced corrugated cardboard. Cut holes all the way through the cardboard to form a ledge to mount the cells on. Be sure to cut away the back of the cardboard to prevent overheating. Label each cell using letters or numbers. You have now made a photovoltaic (PV) celle module.


SILICON SOLAR CELL
LEDGE
CUT-AWAY VIEW
CORRUGATED CARDBOARD MOUNT

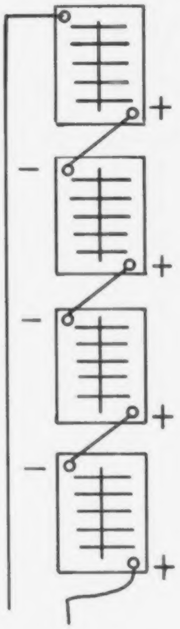
4. First, test the cells. On a clear, sunny day place the cell module in the sun at an angle perpendicular to the sun's rays. Set the voltmeter to the lowest DC reading. Connect the voltmeter to each cell with the alligator clips. Record the voltage of each cell. Each cell should produce the same number of volts (about .5V) and amps (2A). If one of your cells produces a significantly different value, replace it and test the new cell.

5. You are now ready to determine the voltage and amperage of different arrangements of the cells. The first arrangement is in series. Referring to the diagram below, hook two cells together in a series and connect to the voltmeter. Record the voltage and amperage. Now add the third cell and test. Finally, add the fourth and test. Record readings in data table 1.

6. Now test parallel arrangement. Referring to the diagram below, hook the first two cells together and test for voltage and amperage. Add the third and then the fourth. Record the data in table 2.

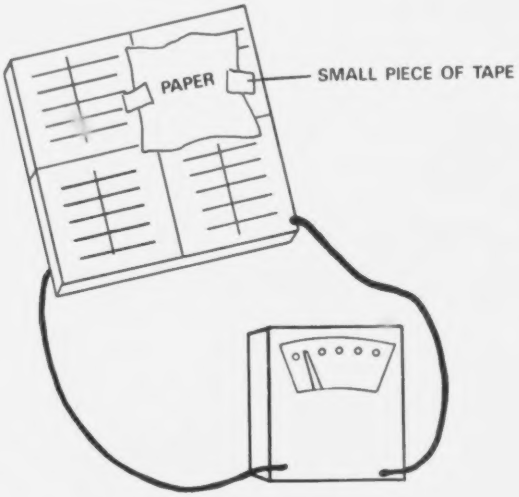


PARALLEL CIRCUIT



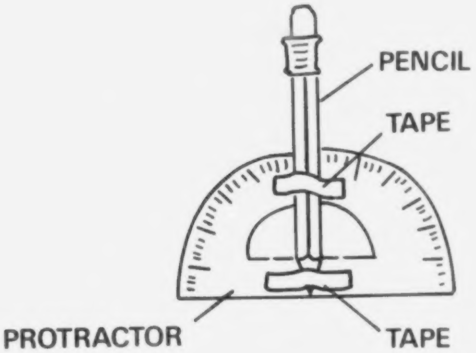
SERIES CIRCUIT

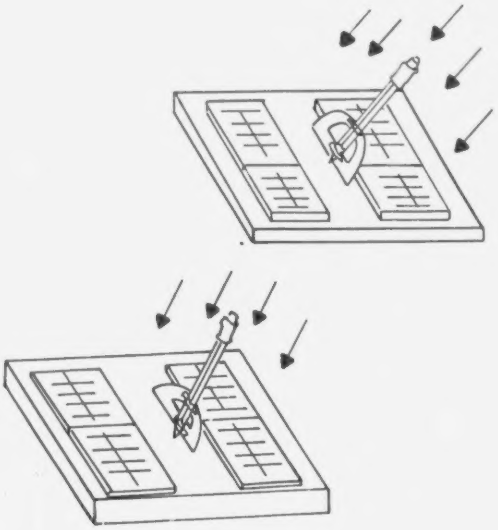
7. Examine the effect of shading. Connect the cells in series. Record the voltage and amperage. Now totally shade one cell with a small sheet of paper or by holding your hand over it. Test for voltage and amperage. Hook the cells in parallel and



SHADING A CELL

8. Examine the effects of changing the angle of the cells. Prepare one cell in a cardboard mount. On a clear, sunny day test the output of the cell at various angles to the sun. Begin with the cell flat on the ground. Increase the angle, taking readings at various angles, until the cell is perpendicular to the sun's rays. Use a pencil taped to a protractor to determine the angle at which the sun's rays are striking the cells. Refer to the diagram below. Record data in data table 4.





Discussion

1. What are the problems associated with mounting a solar cell at a fixed angle to the sun?

   As the sun moves on its daily path across the sky, the angle of the incoming rays changes. If your solar cells are mounted to be at the optimum angle at noon, you will not be able to take full advantage of the sun's energy in the morning or evening. Also, the angle of the incident rays changes seasonally. The perfect solar cell mounting would have to have two features. First, it would have to "track" the sun from dawn to dusk and reset itself for the next day. Second, a perfect system would tilt its angle slightly every day to accommodate seasonal change of declination.

2. What is the main drawback in developing a "perfect" tracking system as described above?

   The technology is available to make such a system possible, but the cost is prohibitive. Remember that the purpose of a solar cell is to produce power. A tracking system uses power. Energy used negates energy produced. The total electrical output would be reduced. The energy gained from such a tracking system would require more energy than that system would produce.

3. Why don't we all have solar cells covering our roofs and eliminate our power bills?

   Large solar cells are very expensive. Also, we have no efficient way to store electricity for use during the night or on cloudy days. An average house would need a basement full of car batteries to get through the night at our standard of living. A break-through in solar cell manufacturing, especially in silicon refining, would certainly be a wonderful turn of events in our energy-hungry world.

Resource

Davis, S. and J. Tiller. Solar Science Projects. Atlanta: Governor's Office of Energy Resources.

The above publication is available from:
Governor's Office of Energy Resources
270 Washington Street, Suite 615
Atlanta, Georgia 30334
(404) 656-5176

TESTING THE ELECTRICAL OUTPUT OF SOLAR CELLS

DATA TABLES
SERIES ARRANGEMENT - TABLE 1

	VOLTAGE	AMPERAGE
2 CELLS		
3 CELLS		
4 CELLS		

Does the voltage or amperage increase with each additional cell? ____

PARALLEL ARRANGEMENT - TABLE 2

	VOLTAGE	AMPERAGE
2 CELLS		
3 CELLS		
4 CELLS		

How does the voltage or amperage change? ____________________

EFFECT OF SHADING - TABLE 3

	VOLTAGE	AMPERAGE
SERIES, UNSHADED		
SERIES SHADED		
PARALLEL, UNSHADED		
PARALLEL, SHADED		

Describe the effects of shading in these tests. ____________________

____

EFFECT OF ANGLE - TABLE 4

ANGLE TO THE SUN	VOLTAGE	AMPERAGE

MEASURING THE HEAT OF A SOLAR COLLECTOR USING A THERMOCOUPLE*

USE WITH:
Physics

TIME:
1-2 class periods

MATERIALS:
1 millivoltmeter
1 meter of copper wire
1 meter of constantan
1 insulated container filled with water and ice
1 piece of styrofoam 60 x 60 x 5 cm
1 piece of aluminum foil (painted black) 60 x 60 cm
1 heat lamp (optional)
1 watch or clock
White glue
Pliers
Wire cutters
Worksheets (included)

Objectives

The student will:

1. Construct a thermocouple that can be used to measure heat difference.
2. Use a thermocouple to measure solar energy in a very simple flat-plate collector.

Background Information

The efficiency of a solar collector is usually determined by the amount of change in the temperature of a collector surface or some type of flowing material such as air or water. Typically, a thermometer is used for measuring this temperature. An alternative method of measuring temperature is a pair of twisted wires known as a thermocouple.

When two wires twisted around each other are heated, an electrical field is set up which creates a current in the wire that is proportional to the heat applied. When another twist of wire is placed in a reference container (usually at 0°), the difference in electrical potential can be measured on a voltmeter, using millivolts as the units. The number of millivolts will turn out to be an accurate measure of the heat on the twist of wire. Most reference books on physics and chemistry contain tables which relate the millivoltage of the thermocouple to the temperature using a set reference such as the ice-water equilibrium mixture. The chart provided in the instructions is such a reference for the thermocouple made with copper and constantan wires. Other wire combinations are possible but require the use of a different chart of conversion. The styrofoam sheet with aluminum foil acts as the collector, and the increase in heat will cause a corresponding increase in the millivoltage.

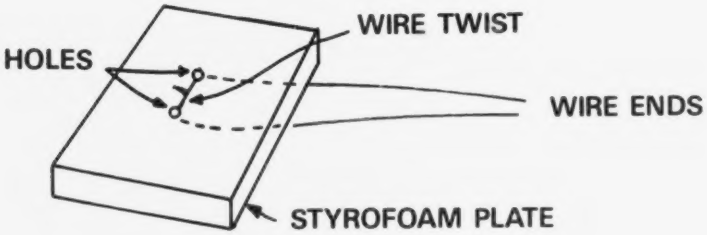
*Based on "Measuring the Heat of a Solar Collector Using a Thermocouple." Refer to the resource listing at the end of the activity.

Procedure

1. Carefully take the piece of copper wire and cut it into two identical pieces.

2. Take the end of the copper wire and twist it together with the constantan wire so that about ten tight turns are made (you may need pliers).

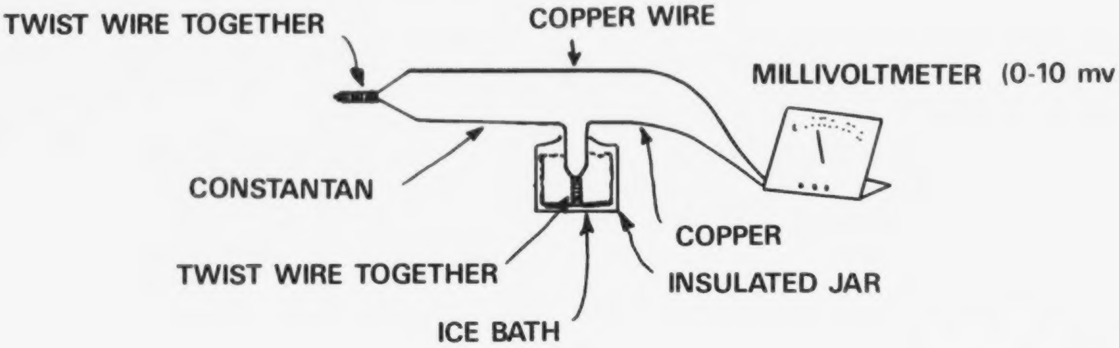
3. With a nail, make two holes in the styrofoam sheet about 2 cm from each other and near the center. Feed the ends of the twisted wire through the holes as far as they can go without untwisting the two wires. Refer to the diagram below.


WIRE TWIST
HOLES
WIRE ENDS
STYROFOAM PLATE

4. Take the end of the constantan wire which is not twisted and twist it together with the other half of the copper wire in the same fashion that you used in step 2.

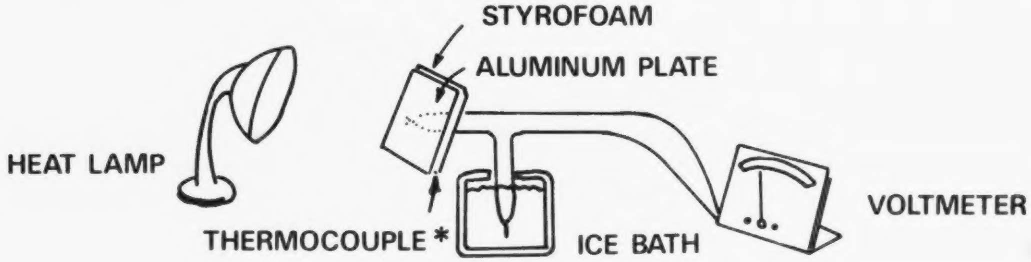
5. CAREFULLY take your equipment outside. (If no sun is available, use the heat lamp inside.)

6. Place the constantan/copper twist in the insulated jar filled with ice and water. Refer to the diagram below.


TWIST WIRE TOGETHER
COPPER WIRE
MILLIVOLTMETER (0-10 mv
CONSTANTAN
COPPER
TWIST WIRE TOGETHER
INSULATED JAR
ICE BATH

7. Carefully glue (in only 2 or 3 spots) the aluminum foil to the outside of the styrofoam sheet, to serve as an absorber plate. Be careful not to rip the aluminum foil on the rough edges of the wire.

8. Place the voltmeter between the two copper wires that are not attached. If the voltmeter does not read a value, switch the terminals so that the voltage reading is positive. Refer to the diagram below.



***BE SURE THERMOCOUPLE IS BETWEEN STYROFOAM AND PLATE**

9. Record the voltage reading every minute for 15 minutes.
10. Carefully take your equipment apart so that all the pieces may be used again.
11. Using the conversion chart, determine the approximate temperature of your collector during each interval that you measured. Record the approximation in the data table.
12. Plot the data, temperature versus time, on a graph.

Discussion

1. Are there any practical uses for a thermocouple?

   Thermocouples made of platinum and rhodium are used to indicate temperatures up to 1600°C. (High temperatures cannot be measured with a mercury thermometer.) A thermocouple can be placed in a remote place which cannot be reached with an ordinary thermometer. Thermocouples provide power for certain satellites by tapping the heat of radioactive isotopes. Plutonium-238 was used as a heat source by the Apollo astronauts to power lunear experiments.

2. How is the electricity produced?

   Under normal circumstances energy cannot be destroyed or created, but it can be changed in form. In this case, heat energy is absorbed by the metallic wires and is changed into electrical energy. The process goes in the opposite direction, too. Electric current causes a wire to heat.

3. Can thermocouples be made of anything other than metal?

Yes. Certain semiconductor materials show thermoelectric properties and perform the heat-to-electricity conversion better than metals. Modules made of stacked wafers of these semimetals may eventually provide great quantities of electricity. Waste heat from rocket exhaust, for example, might be converted to electricity.

Resources

U.S. Department of Energy, "Measuring the Heat of a Solar Collector Using a Thermocouple," Activities: Chemistry and Physics. Washington, D.C. 20545, January 1979.

Omega Engineering, Inc. Complete Temperature Measurement Handbook and Encyclopedia. Stamford, CT, 1985, pp H-20 and T-45.

Thermocouple wire is available from:

OMEGA Engineering, Inc.
P.O. Box 4047
Stamford, CT 06907-0047
ATTN: DEPT. 3000
(203) 359-1660

TEMPERATURE - VOLTAGE READINGS FOR A COPPER - CONSTANTAN THERMOCOUPLE

°F	°C	MILLIVOLTS
0	-17	-.67
10	-12	-.47
20	- 6	-.26
30	- 1	-.04
30	- 1	-.04
40	5	+.17
50	10	+.39
60	15	+.61
70	21	+.83
80	27	+1.06
90	32	+1.29
100	38	+1.52
110	43	+1.75
120	49	+1.99
130	55	+2.23
140	60	+2.47
150	66	+2.71
160	71	+2.96
170	77	+3.21
180	82	+3.46
190	88	+3.71
200	93	+3.97
210	99	+4.22

DATA TABLE

MINUTES	V	APPROXIMATE TEMPERATURE
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

A SOLAR COMMUNITY

USE WITH:
General Science
Economics
American History
Civics

TIME:
2 weeks

MATERIALS:
TVA Solar Materials Packet

Objectives

The student will:

1. Analyze the feasibility of solar homes in this area.
2. Identify those characteristics that facilitate solar building.
3. Analyze the cost-effectiveness of solar heating and other solar projects.
4. Apply effective propaganda techniques in the development of a sales campaign.
5. Demonstrate creativity in reporting research results to the class.

Background Information

In this activity, the students will act as consultants to an imaginary building project. The owners/planners of the proposed West Estates subdivision have come to this class for advice. They are considering the feasibility of making West Estates a model solar subdivision for this area. They own a 350-acre site of rolling woodland. (The teacher and/or class may set any additional conditions concerning West Estates they deem necessary. Such conditions should be recorded, so that everyone is operating with the same information.)

Procedure

1. Have the class brainstorm to develop a list of questions that the West Estates developers will need to answer before deciding on the project.

   Sample question topics:
   a. Cost effectiveness of solar houses.
   b. Number of and design of houses.
   c. How much land should be cleared?
   d. Orientation of houses (which direction will they face?).
   e. Desirable features for houses--water heating, greenhouses, sunrooms, active versus passive heating.

2. Group the questions by topic. Add any relevant topics that were omitted. (Utilize solar materials packets and any other available resources for this research.)

3. Divide the class into groups. Assign each group a set of the question topics to research. (Utilize solar materials packets and any other available resources.)

4. Have groups report back to class. Encourage a variety of reporting techniques (e.g., skits, charts, graphs, illustrated talks).

5. Announce to the class that West Estates' management has been so pleased with the help the class provided in planning this project that they have decided to seek the help of the class in marketing the new homes. Have another brainstorming session to compile a list of positive aspects of West Estates (and solar communities in general) to be emphasized in the campaign.

6. Divide the class into groups according to types of media (below) and have each group design an advertising campaign for West Estates, supplying appropriate samples. Suggested media are:

   a. Newspapers
   b. Brochure to distribute to prospective buyers
   c. Radio/TV
   d. Thirty minute presentation for use with governmental and civic groups

   Have each group pick a product sold through its medium and do an analysis of the techniques used to market the product. (This might be an appropriate time to review propaganda techniques.) Adapt the techniques to the West Estates sales campaign.

7. Have each group present its campaign to the class.

8. If possible, plan a field trip to a solar home (or homes) in your area. Contact your local TVA office for a list of appropriate homes to visit.

Resources

TVA Solar Information Packet contains the following pamphlets:

"Do It Yourself Solar Projects"
"Introduction To Solar Greenhouses"
"Home Energy Environment"
"Introduction To Do It Yourself Solar"
"Landscaping For Energy Conservation"
"Let The Sun Get You In Hot Water"
"Low Cost Solar"
"Natural Cooling"
"Natural Cooling--Decision Guide"
Reprints of: "And the Will Is," by Frederic Lanza
"The Best We Know," by Frederic Lanza
"Residential Energy Tax Incentives"
"Seasonal Sun and Home Operations"
"Solar Energy In New Homes"
"Solar Glazings: A Product Review"
"The Solar Information Service"
"Solar Wall Heaters"
"Sunspace Construction Details"
"Sunspace Operations"
"Which Sunspace For You"

Call TVA's Citizen Action office toll-free: 1-800-362-9250 (Tennessee) 1-800-251-9242 (Alabama, Arkansas, Georgia, Mississippi, Missouri, North Carolina, and Virginia) 632-4100 (Knoxville) or write them at 400 West Summit Hill Drive, Knoxville, Tennessee 37902.

GLOSSARY

Active Solar Energy System:	System which physically transports heat from the collector to the area where the heat in use is "active." The heat is transported by either water or air in most cases.
Ampere:	The SL unit of electric current. The symbol for the ampere is A.
Angle of Incidence:	The angle between incoming light rays and a line perpendicular to the earth's surface.
Calorie:	A unit of energy used to express quantities of heat. When calorie is spelled with a small c, it refers to the quantity of heat required to heat 1 g of water 1°C. When spelled with a capital C, it means 1000 small calories or 1 kilocalorie. Food energies in nutrition are always expressed in Calories.
Carnivore:	An animal that eats other animals.
Coal Age:	The Pennsylvanian Period of geologic history, sometimes called the Age of Cockroaches since these insects grew to over 10 cm in length. Earth was warm and swampy. Dinosaurs had not yet evolved. Coal is carbon from ancient plants which were the dominant organisms at this time.
Conduction:	Heating an object by putting it in contact with a hotter object.
Conductor:	An object or substance through which heat passes easily. Opposite of insulator.
Constantan:	A copper-nickel alloy.
Declination:	The sun's height measured in degrees from the horizon.
Electricity:	A fundamental entity of nature consisting of the movement of electrons.
Energy:	The capacity to do work or to transfer heat.
Environment:	The physical and biological surroundings of an organism.

Equinox:	The first days of spring and autumn, when the length of the day equals the length of the night. The sun is directly overhead at the equator.
First Law of Thermodynamics:	Under normal circumstances, energy cannot be created or destroyed; however, its form may be changed. For example, light is changed to heat when it strikes a black surface.
Flat-Plate Collector:	A box-like device used to trap solar heat for water heating, often mounted on roofs.
Fossil Fuel:	Hydrocarbons created by plants millions of years ago. Included are coal, oil, natural gas (methane), gasoline, kerosene, diesel fuel, propane, oil shale, tar sands, coke, butane, and fuel oil.
Generator:	A device which produces electricity.
Geothermal Energy:	Energy from the heat of the interior of the earth.
Herbivore:	An animal that eats plant matter exclusively.
Hydropower:	Energy available in moving water.
Ice Bath:	A container of ice with enough water to fill in the air spaces.
Insulation:	A substance which prevents or retards the flow of heat.
Isotope:	An atom with either more or less than the average number of neutrons for a given element. Isotopes have the same chemical properties as other atoms of a given element but have a different mass and sometimes are radioactive.
Kinetic Energy:	The energy possessed by a moving object. Physical or mechanical energy. Energy of motion.
Latitude:	The reference lines on maps and globes which run east and west. The equator is 0° latitude.
Mass:	The quantity of matter. Mass, when attracted by gravity, is measured by weighing.

Metabolism:	The chemical changes in living cells by which energy is provided for vital processes.
Millivolt:	One thousandth of a volt of electricity.
Normal:	Perpendicular or at a right angle.
Passive Solar Energy System:	A system which traps heat but does not transport that heat to any other area for use. A greenhouse is an example.
Photosynthesis:	The process by which plants change sunlight to chemical potential energy.
Photovoltaic Cell:	A device which converts sunlight directly to electricity.
Polaris:	The North Star. Indicates true north.
Potential Energy:	Stored energy. Examples are gasoline, water behind a dam, and a charged battery.
Radioactive:	A substance which spontaneously emits radiation.
Solar Energy:	Light and heat from the sun.
Solstice:	The first days of winter and summer. On these days the sun is at its least and greatest declinations, respectively.
Semiconductors:	Solids which do not conduct electricity at low temperatures but are good conductors at high temperatures.
Semimetal:	Elements such as arsenic which are between the metals and nonmetals on the periodic table. They have inferior metallic qualities and are not malleable.
Styrofoam:	A good heat insulator. Rigid, lightweight, and usually white. Used for ice chests, hot drink cups, and home insulation. A polymer of styrene.
System International d'Unites (SI):	French term which translates to International System of Units. It is the name of the modernized metric system which is currently in nearly universal use as the primary system of measurement for the nations of the world.

Thermocouple:	A device for measuring heat by the electricity it produces in metals.
Turbine:	An apparatus with blades that are turned by steam, water, or air.
Turbogenerator:	A turbine built onto a generator so that when the turbine is turned electricity is produced.
Volt:	The SI-derived unit for measurement of potential difference and electromotive force, symbol V.
Voltmeter:	A device for measuring volts.
Watt:	The SI derived unit with a special name used for expressing power. Symbol W. It is defined as that power which gives rise to the production of energy at the rate of one joule in one second.

REFERENCES

Anderson, B., and M. Wells. Passive Solar Energy--The Homeowners Guide to Natural Heating and Cooling. Andover, MA: Brick House Publishing Company, 1981.

Brinkworth, B. J. Solar Energy For Man. New York: Wiley, 1973.

Buckley, S. Sun Up to Sun Down: Understanding Solar Energy. New York: McGraw-Hill, 1979.

Build and Remodel for Energy Efficiency. Available through County Cooperative Agricultural Extension Services, Western Kentucky Regional Office.

Butti, K. and J. Perlin. A Golden Thread: 2500 Years of Solar Architecture and Technology. New York: Van Nostrand Reinhold Company, 1980.

Center for Renewable Resources. Renewable Energy at the Crossroads. Washington, D.C.: CRR, 1985.

Crowther, R. L. Sun/Earth: How to Use Solar and Climatic Energies. New York: Scribner, 1977.

Ewers, W.L. Solar Energy, A Biased Guide. Northbrook, IL: Domus Books, 1979.

Gadler, S. J. Sun Power: Facts about Solar Energy. Minneapolis, MN: S. J. Lerner Publication Company, 1978.

Kreider, J., and R. Kreith. Solar Energy Handbook. New York: McGraw-Hill Inc., 1981.

Leon, G. deL. Energy Forever: Power for Today and Tomorrow. New York: Arco Publishing, 1982.

Maycock, P., and E. Stirewalt. Photovoltaics: Sunlight to Electricity in One Step. Andover, MA: Brick House Publishing Company, 1981.

Mazria, E. The Passive Solar Energy Book. Emmaus, PA: Rodale Press, 1979.

Meador, R. Future Energy Alternatives. Ann Arbor, MI: Ann Arbor Science Publishers, Inc., 1979.

Merrigan, J. A. Sunlight to Electricity. Cambridge: Massachusetts Institute of Technology, 1975.

Metz, D. Superhouse. N.p.: Garden Way Publishers, 1981.

Michaels, T. Solar Energy Utilization. New York: Van Nostrand Reinhold Company, 1979.

Mueller, S. J. and P. Jones. Solar Energy: How to Make It Work for You. N.p.: Butterick Publishing, 1980.

Phillips, O. The Last Chance Energy Handbook. N.p.: Owen Phillips Publishing, 1979.

Power Systems Group/Ametek, Inc. Solar Energy Handbook. N.p.: Chilton Book Company, 1979.

Reif, D. K. Solar Retrofit. Andover, MA: Brick House Publishing Company, 1981

Ridgeway, J. Energy Efficient Community Planning. Washington, D. C.: American Planning Association, 1979.

Ruedisili, D. C., and M. W. Firebaugh. Perspectives on Energy. London: Oxford University Press, 1975.

Tennessee Valley Authority, Catalog of Conservation and Solar Publications. Knoxville: TVA, 1983.

________. Land Between the Lakes, Environmental Education Section. Energy Education - Demonstrations. (Write LBL Environmental Education Section, Golden Pond, KY 42231.)

Winter, Stephen Associates, Inc. The Passive Solar Construction Handbook. Emmaus, PA: Rodale Press, 1983.

CONSERVATION

OVERVIEW

Energy usage surveys in this country indicate that over 90 percent of the materials and goods produced in the United States result from the use of nonhuman energy. During the 19th and 20th centuries, energy demand soared. For most of that time, energy has been abundant, inexpensive, and available in varied forms.

With seemingly limitless supplies of energy, Americans gave little thought to conserving resources. Even when demands for energy exceeded domestic supplies of oil and the United States began to import oil, most Americans assumed that the supply was inexhaustible. In 1973, however, the Organization of Petroleum Exporting Countries (OPEC) stunned the world when its members not only shut off their pipelines to industrialized nations but also more than doubled the price of crude oil. Suddenly Americans began to speak of an "energy crisis." With public attention focused on energy issues, many people began to understand that the fossil fuels on which we depend are finite resources and cannot be relied upon to provide our energy. Both alternative sources of energy and a conservation ethic must be developed.

Conserving energy does not mean depriving yourself of comforts and conveniences. The days of inexpensive energy may be gone, but the enjoyment and opportunities derived from using energy are not. Conservation simply means guarding against waste, being aware of the inefficient ways electricity can be used, and doing something about it. Some conservation measures can involve expenditures (e.g., for special materials or equipment), but there are many ways to conserve energy without spending money.

The first step in any major effort to conserve energy is a change in our society's attitude toward energy consumption. Americans are considered a wasteful, "throw-away" society. We consume many more resources per capita than people in other countries, even those with comparable standards of living. We produce about 150 million tons of solid waste every year, but reclaim only 12 million tons. Not only do we throw away natural resources; we even pay for their disposal. With recycling of wastes, money, energy, and other resources will be saved.

Recycling is one of this country's most promising means for saving energy and resources. Recycling a discarded aluminum can would save enough energy to light a 100 watt light bulb for 20 hours. (Recycling aluminum saves over 95 percent of the energy needed to make aluminum from bauxite.) Other recyclable items pack similar energy punches. For example, recycling paper requires 60 percent less energy; glass requires 35 percent less energy; and scrap metal requires 75 percent less energy. Recycling used oil could save 1.3 million barrels of oil per day. Not only do these place an impact on the economic situation, but recycling also reduces environmental effects.

Not only do Americans waste resources and energy by not recycling, but we also have many wasteful habits and inefficient uses of energy. By changing personal habits and energy usage patterns, purchasing and properly using energy-efficient appliances, and eliminating unneccessary waste in our homes and other buildings, we can conserve energy and at the same time save money. Wasting energy is no longer acceptable in either our behavior or our equipment and facilities. For example, public buildings and individual homes can waste a great deal of heat. Buildings (including schools) are often too warm in the winter and too cool in the summer. Some buildings' window space is poorly planned for energy efficiency. Amount of window space, window orientation, and type of windows--all affect the energy efficiency of buildings. No more than one square foot (1 ft^2) of windows for every 10 square feet (10 ft^2) of floorspace is the ideal window space amount. In cool climates more windows should be installed in south and west walls to maximize solar heat gain, while in warm climates fewer windows should be placed in south and west walls. Double-pane, heat-reflecting, or heat-absorbing glass in windows can provide further energy savings. Improper insulating and sealing contributes to energy inefficiency. If a house is perfectly sealed, no warm air will escape through leaks and be replaced by cold air which must then be heated. Approximately 10 percent of the heating fuel used can be wasted in this manner. Caulking and weatherstripping, along with proper insulation, can significantly reduce waste, especially when we practice energy conservation in our daily habits.

Transportation is another major every-day energy usage in which much energy is wasted. Americans burn nearly 200 million gallons of gasoline in their cars every day. This amounts to half of the total energy consumption in the transportation sector. Our country has 40 percent of the world's automobiles, and half of the automobile gasoline used in the world goes into their tanks. Developments in automobile design and efficiency are on the rise, but we must conserve fuel by properly maintaining personal vehicles, eliminating unneccessary driving, carpooling, and making greater use of public transportation.

Can Americans cut back their energy use without cutting back on the comforts and conveniences on modern living? The answer is yes. In fact, we already have. The 10 percent reduction in our total energy use since 1979 is a good start. We still have inefficiency in many energy-consuming systems, but we now know how to design more efficient vehicles, buildings, and machines so that they require less energy. We can operate the existing systems in a more efficient manner. These efforts to conserve existing resources increase our supplies as if we had created a new kind of fuel.

For most of us, the changes in our use of energy will not be fundamental ones. We will be slightly cooler in winter and warmer in summer. We will make our purchases with a view to efficiency and recyclability, and rely less on throwaway packaging. We will drive smaller cars at slower speeds, make greater use of public transportation, and walk more. We will turn off lights we are not using. In short, Americans will learn to think of energy as money. We will not need to return to the energy use pattern of the past, but we might well return to the spirit of the slogan that was so popular during World War II: "Use it up, wear it out, make it do, or do without."

TO CONSERVE OR NOT TO CONSERVE

USE WITH:
General Science
Physics

TIME:
4-5 class periods

MATERIALS:
Worksheets (included)
  Group 1-Energy Savings
  Group 2-Hot Water Energy Saver
  Group 3-Lighting and Appliances
  Group 4-Automobile Savings
  Group 5-Commercial and Industrial Energy Conservation
OPTIONAL:
Test Your Energy IQ (test and answers)

Objectives

The student will:

1. Present his/her own ideas of how energy is wasted at home and at work.
2. Analyze information on ways to conserve energy.
3. Develop and present a program on how to save energy in a specific area.

Background Information

Experience has proven that the most cost-effective and sensible approach to today's energy problems is to practice conservation of energy. Each of us must realize that we cannot continue using energy at our present rate of consumption. To do our part in conservation, we must look for ways to decrease our use of energy. We can achieve this by being good consumers and changing habits that waste energy. Areas where each of us can have an impact on conserving energy are: heating and cooling our homes; use of hot water in the kitchen, laundry, and bath; lighting and use of appliances in our homes and work places; and wise and proper use of transportation systems.

Procedure

1. Using the background information, introduce the concept of energy conservation to the class.

2. Ask students to help you generate a list of reasons why they think it is important for people to conserve energy. Leave this list in a visible place where students can refer to it.

3. Give the "Test Your Energy IQ" test.

4. Divide the class into groups of six. Assign each group one of the following student activity sheets. They are to complete the activities, then develop a presentation to the class based on their findings. Encourage them to do further research and make visual aids, and tell them that their job is to convince their classmates to conserve energy. You will need at least 4 class periods to complete this procedure: 1 class for students to plan (as a group) how they will complete their group assignments; 1 class for each group to plan its class presentation; 1 class period to set the stage and to take the pre- and post-test; and at least 1 class to hear the presentations. As the teacher, you should give them guidelines on the length of the presentation (for example, 15 minutes per group). You may want to remind them to be cautious when completing activities which require use of electrical appliances, fire, etc. Discuss the importance of communicating with (and in some cases, getting permission from) parents in completing the activity sheets.

For your convenience in selecting student activities the five group titles and individual student worksheet content are tabulated here. There is a unique student activities description sheet for each group which can accompany the separate worksheet.

TO CONSERVE OR NOT TO CONSERVE, teacher's copy
Student Activity Sheets:

Group 1: Energy Savings During Heating and Cooling

1. Effect of closing doors
2. Effect of fire damper position
3. Effect of fireplace on home heating
4. Heating system comparison
5. Comparing window and wall heat loss
6. Window insulation survey

Group 2: Hot Water Energy Savings

1. How much water from leaking faucet
2. Washing dishes with warm and hot water
3. Boiling with or without cover
4. Take bath or shower
5. Heat loss from long pipes
6. Washing clothes with cold and hot water

Group 3: Lighting and Appliance Energy Savings

1. How many watts for seeing
2. Compare appliance brands energy use
3. How lighting diminishes with distance
4. Light source effectiveness
5. Schoolroom lighting survey
6. Home light and appliance survey

Group 4: Automobile Savings

1. Comparing gas mileage
2. Fuel per passenger mile
3. Tire brand/type survey
4. Tire air pressure effects
5. Car weight effects
6. Planning your trips

Group 5: Commercial and Industrial Energy Conservation

1. Find out about your local utility
2. What are "demand charges" and how to reduce them
3. Your school's bills and energy management
4. Industry/home bill comparison and billing units
5. Code requirements and their energy costs
6. Industrial plant energy balance

NOTE: Group 5, Commercial and Industrial Energy Conservation, is more advanced than the other four groups, and you may choose to omit this group. If you plan to use it, you should smooth the way for the students by telling the school system physical plant director, the school principal, local utility official, and a local company plant manager about the activity and its objective. You may be unfamiliar with the concept of electricity demand charge (i.e., a charge to industrial customers for peak power requirements experienced even for an instant during an established period of time.) The kilowatt demand charge is added to the more usual kilowatthour consumption charge.

5. Once all presentations have been made, give the class the "Test Your Energy IQ" test again. Answers to the test are included in this packet. Have the students discuss the energy conservation tips they have discovered and which ones they really believe they will incorporate into their daily lives. Suggest that students test their parents and friends.

Discussion

1. Discuss the energy conservation tips your class has discovered. Which ones do the students think they will really incorporate into their daily lives?

2. Discuss with students how they can spread the knowledge they have attained about energy conservation to family and friends.

3. Discuss what they think will happen to Planet Earth and the human condition if we do not conserve energy in our daily lives.

Resources

Alabama Energy Extension Service. The Car Fitness Book. N.p.: ADECA, 1984.

Alabama Power Company. Energy Bulletin. (Periodical.)

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. ASHRAE Handbook, 1985 Fundamentals. New York: ASHRAE, 1985.

Dorf, R. C. The Energy Factbook. New York: McGraw-Hill, Inc., 1981.

Fowler, J. M. Energy and The Environment. New York: McGraw-Hill, Inc., 1984.

Honeywell Corporation. Energy Conservation With Comfort. N.p.: Honeywell, 1979.

Mass S., ed. Factbook of Electric Food Service Equipment. 34th ed. N.p.: n.p., 1977.

Shurcliff, W.A. Thermal Shutters and Shades. Andover, MA: Brick House Publishers, 1980.

TEST YOUR ENERGY I.Q.

Answer each question below (True or False) and rate yourself on your knowledge of energy use and abuse in the home and on the road.

50 to 45 correct answers	High Energy I.Q.
44 to 40 correct answers	Above-average Energy I.Q.
39 to 35 correct answers	Average; you need to learn more about energy conservation.
Below 35 correct answers	Take the test again and study the answers...because you're probably throwing money away needlessly.

Circle the correct letter.

T F 1. The United States uses more energy per person than any other nation in the world.

T F 2. The United States produces 2/3 of the oil we consume.

T F 3. R-value means the resistance any material has to the flow of heat.

T F 4. On cold winter days a roaring fire in the fireplace can save you energy.

T F 5. In the afternoon you should keep the draperies closed only on all west windows to block out the hot sun.

T F 6. Thermal-lined draperies and outdoor awnings can significantly reduce the energy required for air conditioning.

T F 7. To be comfortable, a home that is dry during the winter must be kept warmer than one with a higher humidity level.

T F 8. Landscaping is important to home energy conservation.

T F 9. You can heat your house faster by turning the thermostat higher than the desired temperature.

T F 10. Weatherstripping doors and caulking windows can only save up to 5 percent of home energy costs.

T F 11. There is no reason to ventilate the attic in the summer if it is well insulated.

T F 12. The furnace/air conditioner will run longer when the air filter is dirty.

T F 13. The lower the temperature setting on your water heater, the less energy you will use.

T F 14. A frosty refrigerator uses less energy because frost acts as an insulator.

T F 15. Food cooks faster in a covered saucepan.

T F 16. You don't have to preheat an oven for broiling or roasting.

T F 17. On especially cold days it is a good idea to get a little extra heat into the kitchen by turning on the oven and opening the oven door.

T F 18. It is usually less expensive to take a bath than a shower.

T F 19. It does not matter where the hot water heater is placed in your home as long as it is in proper running order.

T F 20. The heating and air conditioning system is the major user of residential energy.

T F 21. Refrigerators operate best at 30 to 40 degrees Fahrenheit.

T F 22. The home freezer operates most efficiently when it is 1/2 to 2/3 full.

T F 23. Refrigerators are designed to accept frequent and lengthy door openings without increased operating costs.

T F 24. Small appliances such as toasters, electric skillets and popcorn poppers generally use less energy for specific jobs than a range.

T F 25. If the flame on your gas range is blue, it is not operating properly.

T F 26. Fluorescent and incandescent lights of the same wattage produce the same amount of light (foot candles).

T F 27. Clean surfaces on reflector pans increase the energy efficiency of a range.

T F 28. Put frozen foods directly into the oven. There is no reason to defrost them beforehand.

T F 29. By using cold and warm cycles in your washing machine, you will save energy and money.

T F 30. You will save energy by doing several small loads of wash rather than one large one.

T F 31. Dry as many clothes as possible in each load.

T F 32. Permanent press garments save energy.

T F 33. A clean filter allows the dryer to operate at a higher temperature, saving energy and money.

T F 34. You can save up to 1/3 of your dishwasher operating costs by allowing the dishes to air dry.

T F 35. Trash compactors and waste disposers use a great deal of energy and are not economically feasible.

T F 36. Always remember to use warm water when running the disposal.

T F 37. An iron consumes little energy.

T F 38. About 1/3 of all private automobile mileage is for commuting to and from work.

T F 39. Driving faster uses less energy because operating time is reduced.

T F 40. Always top off your gas tank when filling up your car.

T F 41. On cold days, it saves gas to warm up your car for 5 to 10 minutes before driving.

T F 42. It takes less gas to restart an engine than to idle it for more than one minute.

T F 43. The less air in the tires, the less gasoline you will burn.

T F 44. There is no difference between steel-belted radials and other tires when it comes to gas mileage.

T F 45. The heavier the car, the more gas it uses.

T F 46. Keeping your car in tune will increase gas mileage.

T F 47. An air-starved engine wastes gasoline.

T F 48. The 55 mph speed limit was imposed during the oil embargo to make sure there was enough gas to go around, but soon we'll be driving at higher speeds again.

T F 49. The most efficient way mobile home owners can reduce heating/cooling costs is to install underpinning.

T F 50. Insulating your electric water heater will reduce your utility bill.

ANSWERS

1. TRUE. The U.S. uses more energy per person than any other nation in the world. Although we comprise only about 6 percent of the world's population, we use 36 percent of all energy consumed in the world, and that figure continues to rise.

2. FALSE. The U.S. does not produce 2/3 of the oil we consume. We must import about half of the oil we use.

3. TRUE. R-value does mean the resistance any material has to the flow of heat. The higher the R-value the better the insulation capability of the material.

4. FALSE. A fireplace can cost you energy savings. A fireplace is often a source of heat loss. When the furnace is on, a considerable amount of heated air goes up the chimney.

5. TRUE and FALSE. Keeping the draperies closed on the west windows depends on the time of year. This is true in the summer, but false in the winter. In summer, keep the draperies closed to block out the hot sun. In winter, keep them open and let the sun into the room for extra heat.

6. TRUE. Thermal lined draperies and outdoor awnings block the hot sun and keep your home cooler.

7. TRUE. A home will seem more comfortable if the humidity level is higher. A humidifying device not only increases comfort but saves energy as well.

8. TRUE. Landscaping can affect home energy consumption. A lawn reduces reflective heat in summer. Trees which shed their leaves can provide shade in summer while allowing warming sunlight to reach the house in winter.

9. FALSE. Your house will not heat faster by raising the thermostat higher than the desired temperature. Set it at the proper temperature, and it will cool or heat your home just as quickly without wasting energy.

10. FALSE. Weatherstripping and caulking can save up to 10% of home energy costs.

11. FALSE. Insulation can trap hot air in the attic. Since hot air rises, it will eventually end up in the attic. By ventilating the trapped air, the house will stay cooler and you'll use less energy.

12. TRUE. A dirty air filter will cause your furnace/air conditioner to run longer. Check the air filter about once a month because a dirty filter restricts the flow of air.

13. TRUE. The lower the temperature on your water heater, the less energy you will use. You can regulate the temperature of your water heater with the thermostat. The higher the setting, the higher your energy bill. Check the setting on your water heater.

14. FALSE. A frosty refrigerator uses more energy than a frost free refrigerator. Frost makes the refrigerator work harder to remove warm air. Never let frost accumulate more than 1/4 of an inch.

15. TRUE. Food cooks faster in a covered saucepan. The kitchen will stay cooler as well. Turn the heat off a few minutes before the food is completely cooked. Retained heat will complete the cooking.

16. TRUE. You do not have to preheat an oven for broiling or roasting. In fact, any food that cooks for more than one hour does not require a preheated oven.

17. FALSE. Using your oven is a very costly way to heat your kitchen.

18. FALSE. It usually takes twice as much hot water for a bath as for the average shower. This can run up your energy bill because heating water accounts for as much as 20 percent of home energy expenses.

19. FALSE. Place the water heater as close as possible to areas where hot water is needed. The longer the pipes, the greater the heat loss. If the pipes are exposed, it is a good idea to insulate them. Insulated pipes keep the water hotter.

20. TRUE. The heating and air conditioning system is the major user of residential energy; home heating and air conditioning represents as much as 70 percent of your home energy bill.

21. TRUE. Refrigerators operate best at 30 to 40 degrees Fahrenheit while freezers operate best at 0 degrees Fahrenheit. Lower settings are unnecessary and waste energy.

22. FALSE. The home freezer is most efficient when filled to capacity.

23. FALSE. It costs money and energy every time a refrigerator door is opened.

24. TRUE. Small appliances often use less energy than a range. They are designed to do specific jobs and make cooking easier.

25. FALSE. If the flame on your gas range is blue, it is operating correctly. If the flame has traces of yellow, the burners have become clogged and should be cleaned.

26. FALSE. Fluorescent and incandescent bulbs of the same wattage do not produce the same amount of light. Fluorescent lights produce 3-1/2 times more light than incandescent bulbs of the same wattage.

27. TRUE. Clean, reflective surfaces increase efficiency. Also, if your oven is self-cleaning, wait until after you have used the oven and less energy will be required for the cleaning process.

28. FALSE. Putting frozen food directly into the oven requires more cooking time. Plan ahead and thaw frozen food in your refrigerator before cooking.

29. TRUE. Much of the energy used in doing your family wash goes to heat the water. Using cold water as often as possible should decrease your energy bill.

30. FALSE. A large-capacity washer saves energy by handling in one load what a small washer must do in two loads.

31. FALSE. Do not dry as many clothes as possible in each load. You should sort the clothes by thickness before you place them in the dryer. It takes a longer cycle for slow-drying items.

32. TRUE. Be sure to take permanent press garments out of the dryer as soon as the cycle is complete. You probably will not have to spend energy ironing them.

33. FALSE. A clean filter saves energy and money by allowing a high rate of flow of clean hot air and reducing drying time.

34. TRUE. Turning off the dishwasher after the rinse cycle is complete or using the overnight dry setting can save you 1/3 of dishwasher operating costs.

35. FALSE. Trash compactors and waste disposers consume relatively small amounts of energy.

36. FALSE. Use cold water when running the disposal. It is designed to work with cold water, and since hot water is a prime user (20 percent) of residential energy, this will save energy and money.

37. FALSE. A hand iron consumes as much energy as ten 100 watt light bulbs. Permanent press items save ironing time. Iron large batches of clothing at one time to avoid wasting energy reheating the iron.

38. TRUE. Join a carpool.

39. FALSE. The faster you drive, the more gasoline you burn. That's why there is a 55 mph national speed limit.

40. FALSE. When filling your car, remove the nozzle as soon as it cuts off and avoid spillage.

41. FALSE. The best way to warm up a car is to drive slowly until the engine reaches proper operating temperature.

42. TRUE. Safety and theft considerations aside, it takes less fuel to restart than to let a car idle for a minute or more.

43. FALSE. Check air pressure in your tires regularly. Underinflated tires increase gas consumption.

44. FALSE. Properly inflated steel-belted radials give better mileage and last longer.

45. TRUE. The lighter the car, the less gas it uses. Always remove unnecessary weight from the car.

46. TRUE. A car that is in tune will get better mileage. The smoother your engine runs, the less energy it will require to operate.

47. TRUE. An air-starved engine will waste gasoline. Keep the air filter clean and your mileage should increase.

48. FALSE. The 55 mph speed limit was imposed to conserve gasoline, but the speed limit is here to stay. Lower highway speeds save energy.

49. TRUE. Underpinning or a "skirt" is the most accessible and practical method of reducing heat flow for mobile homes.

50. TRUE. An investment of $15 to insulate your electric water heater probably will pay you back for your efforts in about 12 months.

GROUP 1

ENERGY SAVINGS DURING HEATING AND COOLING

Experience has proven that the most cost-effective and sensible approach to today's energy situation is energy conservation. Each of us must realize that we cannot continue consuming energy at the present rate. To correct this, we must look for ways to decrease our use of energy.

Heating and cooling our homes account for most of our residential energy costs. The purpose of these activities is to discover some of the important ways to decrease the consumption of energy in our homes.

Your group is to complete the following six activities and then develop a group presentation to be given to the rest of the class.

First, you will want to meet as a group to discuss your assignment and to decide who will be responsible for which activities. For example, if there are six people in the group you may decide to each choose one of the six activities. Once each person has completed his/her assignment, you will want to meet again as a group to discuss your findings and prepare your group presentation to the class.

ACTIVITY 1

The purpose of this activity is to determine whether or not energy can be conserved by closing doors to unoccupied rooms. You will need a thermometer and the chart below for recording data.

ROOM TEMPERATURE CHART: Record data for several rooms, i.e. bedrooms, bathrooms, etc. Measure the temperature at a spot in the middle of each room.

ROOM Closed	Temperature W/Door Open	Temperature W/Door

Choose:

A. A time when you can leave your home's heating system set at a constant temperature for several hours.

B. A time when weather and/or sun conditions are fairly constant so it will not invalidate your data. For example, after dark is a good time. If you start with doors closed, wait at least 2 hours before recording the temperature with doors open. What can you conclude about closing doors to unoccupied rooms and energy conservation? If you have air intake vents, do you think opening or closing them would make a difference?

ACTIVITY 2

The purpose of this activity is to determine whether or not energy is conserved by leaving a fireplace damper closed. You will need access to a home damper, a watch, and the chart below for recording data. Start by opening the damper in your fireplace. Then record the time when the heating system kicks on and off. Do this for at least one hour. Close the damper and wait one hour. This gives the house temperature time to stabilize. Record the information again. Does the heating system run with the damper closed or open? Remember not to (1) change the thermostat while the experiment is in progress, or (2) choose a time to conduct the experiment when sunshine or weather changes will invalidate your data.

DAMPER CHART

DAMPER OPEN		DAMPER CLOSED	
Kick-on Time	Kick-off Time	Kick-on Time	Kick-off Time

TOTAL ON TIME (min) =

TOTAL ON TIME (min) =

ACTIVITY 3

The purpose of this activity is to determine whether or not energy can be conserved by building a fire in the fireplace while the heating system is operating. You will need access to a home with an open fireplace, a watch, and the chart below for recording data. Leave the thermostat for the home's heating system set on a constant temperature during the experiment. With no fire in the fireplace, record the time on your watch each time the heating system kicks on and off. Then, using all safety precautions, build a fire in the fireplace. CAUTION: Have a parent or someone who is experienced assist you. Record the data. Does the heating system run more with or without the fire?

FURNACE CHART

NO FIRE		FIRE	
Furnace Kick On Time	Furnace Kick-Off Time	Furnace Kick-On Time	Furnace Kick-Off Time

No. of Times Furnace Kicked On:	No. of Times Furnace Kicked On:
Total Minutes Furnace Ran:	Total Minutes Furnace Ran:

ACTIVITY 4

The purpose of this activity is to determine whether or not energy can be conserved by choosing a particular heating system for your home. You will need the chart below and transportation to stores or outlets carrying heating systems such as furnaces and heat pumps. Go on a shopping spree to several different stores or outlets that carry heating systems. Record the data on the chart below, or organize a chart that will better fit the data you accumulate. How does the efficiency of one system compare to another? Does one system have advantages or disadvantages over another for consumers?

HEATING SYSTEM CHART

BRAND	INITIAL COST	CAPACITY BTU/HR	ESTIMATED ANNUAL FUEL CONSUMPTION

ACTIVITY 5

The purpose of this activity is to determine how glass compares to wall materials in conserving energy. You will need a thermometer, the chart below for recording data, and access to a home with windows on the north, south, east, and west sides. Start by measuring the temperature of the inside glass (put the thermometer directly on the glass) of 4 windows, one each on the north, south, east, and west sides of the house. Then measure the temperature of a spot on the north, south, east, and west walls which is at least 3 feet away in all directions from a door or window. Measure the temperature at each of the corresponding spots on the OUTSIDE walls and windows. Record all data.

WINDOW CHART

INSIDE WINDOW	TEMP	OUTSIDE WINDOW	TEMP
North	______	North	______
South	______	South	______
East	______	East	______
West	______	West	______

INSIDE WALL	TEMP	OUTSIDE WALL	TEMP
North	______	North	______
South	______	South	______
East	______	East	______
West	______	West	______

Which material (wall or window) has the greatest variation in degrees from inside to outside? Does compass direction determine anything? If you were designing an energy efficient home, how would you apply this data?

ACTIVITY 6

The purpose of this activity is to determine if choices of window coverings will conserve energy. Pretend you own your home and are just moving in. You are in the process of choosing coverings for all your windows. Of course you want them to look good, but you are also concerned with whether or not they will affect energy consumption. You will need the chart below to record data and transportation to stores or outlets which sell window coverings. You may need to design another chart that better fits the data you accumulate. Go on a shopping spree to several different stores. Tell the shop attendant about your assignment and ask if they have information on heat loss for fabrics or other window coverings that they sell.

WINDOW COVERING CHART

KIND	COST	HEAT LOSS (BTU/HR)	OTHER

GROUP 2

HOT WATER ENERGY SAVINGS

Experience has proven that the most cost-effective and sensible approach to today's energy situation is energy conservation. Each of us must realize that we cannot continue consuming energy at the present rate. To make any correction of this we must look for ways to decrease our use of energy in our homes. Perhaps more than in any other area of energy conservation, our daily routine habits affect energy consumption in the amount of hot water we use (e.g., the length of time we spend in the shower, etc.).

In these activities, we will explore ways to decrease hot water consumption through habit changes and by being informed consumers. Your group is to complete the following six activities and then develop a group presentation to be given to the rest of the class. Your presentation should be based on the data you collected during completion of the activities. First, you will want to meet as a group to discuss your assignment and to decide who will be responsible for which activities. For example, if there are six people in the group you may decide to each choose one of the six activities. Once each person has completed the assignment, you want to meet again as a group to discuss your findings and prepare your group presentation to the class.

ACTIVITY 1

The purpose of this activity is to determine how much water is wasted by leaking faucets. You will need a faucet over a sink, a measuring cup, a watch with a second hand, and the chart below. First, turn the faucet on just enough to get one drop every second. Place the measuring cup under the faucet. Record the time. Then record the time when one cup is full. Repeat the procedure for 2 drops per second and 3 drops per second. Calculate how much water would be wasted in a day, a month, and a year for each drop situation.

WATER DROP CHART

DROPS/ SECOND	START TIME	END TIME	TOTAL TIME	WATER WASTED DAILY (CUPS)	WATER WASTED DAILY (LITERS)	WATER WASTED MONTHLY (LITERS)	WATER WASTED YEARLY (LITERS)
1							
2							
3							

* Conversion Factor: 236.8 ml/cup

ACTIVITY 2

The purpose of this activity is to determine whether warm water cleans as well as hot water. The assumption behind this experiment is that, if we would clean more household items with warm water, we could save the energy required for hot water. You will need several soiled dishes or pots, dishwashing detergent, and access to hot and cold running water. Choose dishes soiled with different kinds of food. For example, two dishes with bacon grease, two dishes with sugary juices, two dishes with melted cheese, etc. Clean one dish in hot water and one in warm water. Do everything the same except for the temperature of the water. That is, use the same amount of detergent, and scrub for the same amount of time. Dishes must be washed one at a time to avoid unequal soaking time. Record which dish of each pair was cleaned satisfactorily and which dish was not. What are your conclusions about cleaning with warm water? Are some, all, or no situations acceptable for use of warm water? What if you were cleaning bathtubs, tile, and basins instead of dishes?

DISH CLEANING CHART

Mark an X in the appropriate columns

DISHES SOILED WITH:	HOT CLEAN	WATER NOT CLEAN	WARM CLEAN	WATER NOT CLEAN	COMMENTS

ACTIVITY 3

The purpose of this activity is to determine how much heating time can be saved boiling water with a lid on the pot. The assumption is that if we can find ways to reduce the time a stove stays on during cooking, then we can conserve energy. You will need access to a stove, a pot with a see-through lid, a measuring cup, a watch with a second hand, and the chart below. Since you will be boiling water and need to watch the kettle, you should ask a parent to stand by as co-pilot while you perform the boiling. First, put one cup of water in the pot. Turn the stove on high and record the time on your watch. Then record the time when the water breaks into a rapid boil. Let the pot and stove cool to room temperature. Repeat this procedure with the lid on the pot. Is boiling time more, less, or the same with and without a lid? What can you conclude about people who are in the habit of cooking with lids?

WATER BOILING CHART

POT	TIME STOVE TURNED ON	TIME RAPID BOILING BEGINS	TOTAL TIME (MIN)
WITH LID			
WITHOUT LID			

ACTIVITY 4

The purpose of this activity is to compare the amount of water used in a bath and a shower. You will need adhesive tape, an empty two liter plastic container, access to a tub/shower, and the chart below. Start by calibrating the tub. To do this, pour exactly 20 liters of water into the tub. Mark the water level with a piece of good quality adhesive tape. Pour in 20 more liters and mark the 40 liter water level with tape. Repeat until tub is nearly full. Once the tub is calibrated, drain the water in the tub to a comfortable depth. Record the depth of the water. Next day, take a shower with the tub plugged. Take a comfortable amount of time to clean your body adequately. Record the depth of the water. If possible repeat the experiment several times, or get other family members to record data for you. What can you conclude about the amount of water you and your family use in bathing/showering?

BATH/SHOWER CHART

DATE	BATH/No. LITERS	SHOWER/No. LITERS

ACTIVITY 5

The purpose of this activity is to show that heat is lost when water travels from the home's hot water heater through pipes to a faucet or other outlet. The assumption behind this activity is that more energy is lost when the pipe length between heater and faucet is longer. You will need access to a home with several faucets, a metal stem thermometer, and the chart below. First, locate your home's hot water heater. Draw a sketch of your house plan and locate the heater and all faucets on the plan. Then go to each faucet one at a time and turn on the hot water. When the water is the hottest it can be, measure the temperature of the water and record your data on the chart.

HOT WATER PIPE CHART

HOT WATER HEATER TEMP IS SET ON __________

FAUCET LOCATIONS	MAXIMUM WATER TEMPERATURE	TIME TO REACH TEMPERATURE (MIN)

ACTIVITY 6

The purpose of this activity is to compare clothes cleaned in hot or cold water. The assumption is if more clothes can be cleaned in cold water, then energy used to heat hot water wash loads can be conserved. You will need several clean white rags, a permanent marker or laundry pen, access to a washer, and the chart below. First, stain 2 rags each with dirt, grease, fruit juices, tomato sauce, etc. Do not put more than one kind of stain on one rag. Mark with permanent marker what kind of stain you put on each rag. Then divide the rags into two loads. There should be one rag of each stain in each load. Then wash one load in cold water only and one load in hot water only. Use the same amount and kind of detergent for both loads. Compare which stains are cleaned in each load. What can you conclude about how well particular stains come out in hot or cold water? Is hot water necessary for cleaning in all, some, or none of the stains?

STAIN REMOVAL CHART

Record each type of stain. Mark to indicate cleaned or not cleaned.

	HOT WATER		COLD WATER	
STAIN	CLEANED	NOT CLEANED	CLEANED	NOT CLEANED

GROUP 3

LIGHTING AND APPLIANCE ENERGY SAVINGS

Experience has proven that the most cost-effective and sensible approach to today's energy situation is energy conservation. Each of us must realize that we cannot continue consuming energy at the present rate. To make any correction of this, we must look for ways to decrease our use of energy.

It is easy to use more light than you need. More than 16 percent of the electricity we use in our homes goes into lighting.

The purpose of these activities is to discover ways to decrease the consumption of energy when lighting and using appliances in our homes.

Your group is to complete the following six activities and then develop a group presentation to be given to the rest of the class. Your presentation should be based on the data you collected during completion of these activities. First, you will want to meet as a group to discuss your assignment and to decide who will be responsible for which activities. For example, if there are six people in your group, you may decide to each choose one of the six activities. Once each person has completed the assignment, you will want to meet again as a group to discuss your findings and prepare your group presentation to the class.

ACTIVITY 1

The purpose of this activity is to discover how much lighting wattage is necessary to complete a project such as sewing, reading, etc. The assumption behind this experiment is, if we would use light bulbs with decreased wattage, then we could save energy wasted on unnecessary lighting. You will need a lamp next to a comfortable chair in a dark room; several different bulbs with different wattages (for example, 25 watts, 40 watts, 60 watts, 75 watts, 100 watts); a book to read, something to write, or a sewing project; a watch; and the chart below for recording data.

Starting by putting the largest watt bulb in the lamp. CAUTION: Unplug the lamp each time you change the bulb, and allow the bulb to cool before you touch it. Sit in the chair and spend 10 minutes working on your project. Record on the chart how well you were able to work on it. For example: Did you experience glare, did it seem difficult to work, was it too dark, etc? If you are sewing or writing, you may choose to mark the work done under different wattages so that you can compare the work quality later. Then, change the bulb (in descending order of wattage) and work 5 minutes under each bulb. Record your data each time. NOTE: The room should be dark other than the light from your lamp. Do not change the lamp position. Which wattage was best for your project? What was the minimum wattage necessary to do satisfactory work? Can you draw conclusions about how much light you waste or do not waste in your daily routine? What other factors affected the quality of your work?

PROJECT LIGHTING CHART

WATTAGE	COMMENTS	RATE YOUR WORK QUALITY (1 = worst, 5 = best)
		1 2 3 4 5
		1 2 3 4 5
		1 2 3 4 5
		1 2 3 4 5
		1 2 3 4 5
		1 2 3 4 5

ACTIVITY 2

The purpose of this activity is to determine if some appliances on the market consume more energy than others. You will need the chart below and transportation to stores or outlets carrying kitchen appliances. Choose four appliances for your experiment. For example, toaster, microwave, mixer, blender. Go on a shopping spree to several different stores. Tell the shop attendant about your assignment and ask if they have information on the energy efficiency of appliances they sell. Record the data you find. You may decide to design a better chart for organizing your data.

APPLIANCE CHART

APPLIANCE	BRAND	COST	WATTS*	VOLTS*	AMPS*

*(W) watts = V x A   NOTE: x = "times"

What appliance would you choose to purchase? Why? What other factors besides energy efficiency affected your decision?

ACTIVITY 3

The purpose of this activity is to determine to what degree the distance a light is away from a work site affects our ability to do satisfactory work. Although sharp differences in lighting intensity should be avoided, the use of "task lighting" (i.e., a light focused on the work at hand rather than uniform room lighting) can result in reduced energy consumption. You will need a stable standing lamp with a 60-watt bulb, a 20-foot extension cord, a comfortable chair, a watch, a project to do (such as a book to read, something to write, or a sewing project), and the chart below for recording data. Start by turning all other lights in the area off. Put the lamp next to your chair. Sit and work on your project for 5 minutes. Record on the chart how well you were able to work on your project. For example, if it seemed difficult to work, why was it too dark, etc? (If you are sewing or writing, you may choose to mark the work done during each 5 minutes of work so that you can compare the work quality later). Then move the lamp 5 feet away from you. Repeat the experiment. Do this for 10, 15, and 20 feet away. Work for 5 minutes and record your data each time. At which distance could you see your work the best? What was the maximum distance at which you could do satisfactory work? What other factors affected the quality of your work?

DISTANCE LIGHTING CHART

LAMP DISTANCE	COMMENTS	RATE YOUR WORK QUALITY (1 = worst, 5 = best)
0 FEET		1 2 3 4 5
5 FEET		1 2 3 4 5
10 FEET		1 2 3 4 5
15 FEET		1 2 3 4 5
20 FEET		1 2 3 4 5

How can one conserve energy in terms of lighting amount?
Can quality work be done with few lights on?

ACTIVITY 4

The purpose of this activity is to research the efficiency of different kinds of light. You will need the chart below and transportation to several different lighting outlets. Go on a shopping spree. Tell the shop attendant about your assignment and ask if they have information on the efficiency of different kinds of lights sold at their store. You will be looking specifically for lumens per watt. Record the data you find. Find data for the kinds of light listed below and any other kinds you discover.

KINDS OF LIGHTING CHART

KIND OF LIGHT	LUMENS/WATT	COMMENTS
Incandescent		
Fluorescent		
Mecury Vapor		
Sodium Vapor		

What kind of lighting would you choose to install if you were building your own home, installing street lights, building an office building, filming a movie, etc? Which kind of lighting is most energy efficient, and why?

ACTIVITY 5

The purpose of this activity is to determine if your school is conserving the most energy possible through lighting. You will need the chart below. Contact your school custodian and ask to set up an appointment with him/her to help you do an inventory of lighting in your school. Then choose a classroom or two, a parking lot, the office, and a cafeteria or auditorium to collect data. It is not necessary to inventory EVERY room in your school. Then go with the custodian to each room or area which you have chosen and inventory the amount of light consumed using the chart below. Be sure to determine the room size of each room used for data. Also, try to determine if energy-efficient bulbs have been used, and whether some of the lights can be turned off while others are left on.

SCHOOL LIGHTING CHART

ROOM	NO. OF BULBS	KIND OF BULBS	WATTS	NO. OF LIGHT SWITCHES

In each room ask the following questions: How is lighting controlled? For example, can you turn only half the lights on at one time? Or can only the lights nearest the window be turned off? What recommendations can you make to increase lighting efficiency at your school?

ACTIVITY 6

The purpose of this activity is to determine if your home is conserving energy in lighting and appliances used. Inventory the wattages of all easily accessible lights and appliances. Most appliances have the wattage recorded on a sticker or etching. Do not try to move large appliances. If no wattage is given on the appliance, see if voltage and amperage is given. In most cases, you can compute wattage by multiplying the number of volts (i.e., 120) by the number of amps. Record all data. Do not work around electricity with wet shoes or hands. You do not need to include all lighting and appliances in order to determine whether lighting and appliance energy is conserved in your home.

HOME APPLIANCE AND LIGHTING CHART

APPLIANCE	WATTAGE	ESTIMATED HOURS USED/YEAR

Did you find lights that were turned on but not being used? Could a light bulb of smaller wattage be used in any location? Did you find any unattended appliances in use; e.g., radios, televisions, fans? Are dishwashers, clothes washers, and dryers used only when there are full loads to wash or dry? Do you think that your family could save energy and money by improving their conservation of energy?

GROUP 4

AUTOMOBILE SAVINGS

Experience has proven that the most cost-effective and sensible approach to today's energy situation is energy conservation. Each of us must realize that we cannot continue consuming energy at the present rate. We must look for ways to decrease our use of energy.

There are more than 100 million registered automobiles in the United States. A typical car, with an average fuel economy of about 15 miles per gallon, travels about 10,000 miles each year and uses well over 650 gallons of gasoline. This means that private automobiles consume some 70 billion gallons of gasoline each year. The importance of individual gasoline conservation cannot be overemphasized.

The purpose of these activities is to discover some of the important ways to decrease consumption of energy in transportation.

Your group is to complete the following six activities and then develop a group presentation to be given to the rest of the class. Your presentation should be based on the data you collect during completion of these activities. First, you will want to meet as a group to discuss your assignment and to decide who will be responsible for which activities. For example, if there are six people in your group, you may decide to each choose one of the six activities. Once each person has completed the assignment, you will want to meet again as a group to discuss your findings and prepare your group presentation to the class.

ACTIVITY 1

The purpose of this activity is to compare the energy efficiency of automobiles on the market today. You will need transportation to car sale lots and the chart below. Choose 3 types of cars. For example: large luxury cars, medium size family station wagons, and small sports cars. Some other examples might be mini-vans, full-size trucks, or small-size trucks, etc. Visit several car sale lots and collect information on several makes and models within your 3 categories. Record all data. Create a better chart if necessary for organizing your data.

AUTOMOBILE CHART

LOT	MAKE	MODEL	GAS MILEAGE	COST	FUEL COST PER YEAR

Which car is most energy efficient? What other factors would you consider in buying a car? Which car would you like to buy if you could, and why?

ACTIVITY 2

The purpose of this activity is to become aware of alternative types of transportation and how much energy is consumed by each. You will need access to a telephone and the chart below. Calculate the gas (or energy) per person used if they go the same distance on a bus, a car, a motorcycle, a passenger airplane, a bicycle, and any other forms of transportation you can think of. To do this, call your local public service bus office or school bus garage and ask how big the average bus tank is, how many people can ride on a full bus, and the average gas mileage of a bus. Call the maintenance division at an airport to get similar information for an airplane. Call shops or use your own information to get data on cars, motorcycles, etc. Record all data.

TRANSPORTATION CHART

FORM OF TRANSPORTATION	GAS/MILE/PERSON	OTHER

Which form of transportation is most energy efficient? What other factors must you consider in choosing transportation? Which form of transportation would you choose most often, and why?

ACTIVITY 3

The purpose of this activity if to discover whether or not tires affect the energy efficiency of a car. You will need transportation to several tire outlets and the chart below. Choose a car make and model. It can be your own car, the family car, or just a car you wish you had. Then visit several tire outlets. Talk to the shop attendants and tell them about your assignment. Collect information on which tire would be the most energy efficient for your car and why. Record all data. Create a better chart if necessary for organizing your data.

TIRE CHART

TIRE MAKE	SHOP	TIRE MILEAGE	EXPECTED LIFE	COST	COST PER MILE

Which tire would you choose to buy for your car, and why? Which tire gives you more per cost? Would different models of cars be more energy efficient with different tires?

ACTIVITY 4

The purpose of this activity is to determine if tire pressure affects gas mileage in a car. You will need access to a car and the car's owner's manual, and the chart below. First, check the tire pressure (or have someone check for you) on your car. Record the pressure and the mileage on the odometer. Fill the tank and record gallons put in tank. Wait until the car is driven 50 miles. Calculate the gas mileage. Then check the owner's manual for the maximum load pressure for the tires. Have the tires filled to that pressure and repeat the process above. Record the data.

TIRE PRESSURE CHART

TIRE PRESSURE	GAS MILEAGE

At which pressure did the car get the best gas mileage?

ACTIVITY 5

The purpose of this activity is to determine if the weight of a car significantly affects gas mileage. You will need access to a car, something that weighs 300 pounds*, and the chart below. First, record the mileage on the odometer and fill the tank. When the car has consumed 1/4 tank, record the mileage on the odometer again. Then, put 300 pounds (sand bags, a chunk of steel, etc.) in the back of the car. When the car has consumed another 1/4 tank of gas, record the mileage again. Calculate the difference in mileage with and without the 300 pounds weight.

*Six 50-pound bags of sand or top soil, or your parents.

CAR WEIGHT

WITHOUT WEIGHT	WITH WEIGHT
Mileage at start = of 1/4 of tank ________	Mileage at start = of 1/4 of tank ________
Mileage at end of = 1/4 of tank ________	Mileage at end of = ________
DIFFERENCE	DIFFERENCE

In which situation did the car go more miles? Which situation was most energy efficient? What does this say about large and small cars on the market today?

ACTIVITY 6

The purpose of this activity is to determine if planning a route helps save energy. You will need a map of your community, 4 friends or relatives who drive, and 4 copies of chart below. Choose 5 points of destination on a map. The points could be stores or street corners or homes. Then ask your four friends separately to visit the five destinations. Ask them to record how many miles they drive between spots. Ask only two of them to plan their routes. Don't ask the other two to do anything special. Collect the charts after they have completed the route.

MILEAGE CHART

NAME:______________________________

MILEAGE AT START =
MILEAGE AT FIRST STOP =
SECOND STOP =
THIRD STOP =
FOURTH STOP =
FIFTH STOP = __________

TOTAL MILEAGE =

Which person took the least amount of miles to complete the course? Why? Was it one of the members who planned?

GROUP 5 (OPTIONAL)

COMMERCIAL AND INDUSTRIAL ENERGY CONSERVATION

Experience has proven that the most cost-effective and sensible approach to today's energy situation is energy conservation. Each of us must realize we cannot continue consuming energy at the present rate, and we must look for ways to decrease our use of energy. Commercial ventures and industrial plants, faced with rising energy costs and mindful of the corporate balance sheet, must find ways to use energy more effectively. The purpose of these activities is to discover how commerce and industry are billed for energy use, how large these bills can be, and how they can be reduced.

Your group is to complete the following six activities and then develop a group presentation to be given to the rest of your class. Your presentation should be based on the data you collected during completion of these activities. First, you will want to meet as a group to discuss your assignment and to decide who will be responsible for which activities. For example, if there are six people in your group, you may decide to each choose one of the six activities. NOTE: The two people who are to do Activities 1 and 2 should both go together to meet with a utility representative. Once each person has completed the assignments, you will want to meet again as a group to discuss your findings and to prepare your group presentation.

ACTIVITY 1

You will need to work closely with the person doing Activity 2. The purpose of this activity is to discover what energy sources are used to supply local power to your homes, school, and businesses. For example, in 1977 nationally, approximately 46 percent of our electricity was produced using coal as a primary energy source, 17 percent using petroleum, 14 percent using natural gas, 12 percent using nuclear energy, 10 percent using hydroelectric resources, and less than 1 percent using geothermal, waste, wood, and other resources. You need to find out what kinds and percentages of energy sources were used to produce the power your local utility distributed. To do this, it is suggested that you telephone the manager's office at your local utility company and briefly describe this assignment, and request an opportunity to meet with a utility representative who can provide information to you. A copy of the annual reports of your local utility and of their suppliers may be helpful.

Try to determine the answers to the following questions:

A. Has the prime energy source for power generation changed in the past ten years? From what to what? What are the reasons for the change?

B. Can the utility company give you forecasts of future power sales which will allow you to draw a graph? How do they propose to supply increased power requirements? What prediction do they make about future rate increases?

C. Write a two-page summary giving your reactions to the interview and your degree of confidence that the utility company can supply future power needs.

D. If you were buying a house, would it be an all-electric home?

ACTIVITY 2

You will need to work closely with the person doing Activity 1. The purpose of this activity is to discover how the billing of commercial and industrial customers differs from residential billing and whether "demand charges" and "time of day rates" are used by your utility company. You need to become familiar with the "demand charge" concept, so that you can explain it to your class. To do this, it is suggested that you (or your classmate) call the manager's office at your local utility company and, briefly describing your assignment, request an opportunity to meet with a utility representative who can provide information to you.

Residences are usually charged only for the amount of power consumed; i.e., how many kilowatthours you use during the billing period. Commercial and industrial accounts are usually charged not only for how much power they use but also for the maximum amount of power which they draw at any one instant during a pre-set twelve month period; i.e., the maximum number of kilowatts they need at any one time. The demand charge is made to reflect the commercial or industrial customer's share of the utility's investment in power-generating capacity. For example, an aluminum producer would have a higher demand charge than an office supply company.

Try to determine the answers to the following questions:

A. Does your local utility make a demand charge for commercial and industrial customers? What is a demand charge? How is it figured?

B. Energy management can lower energy costs for commerce and industry. One way is to use fewer kilowatthours. Another way is to lower the demand and, therefore, the demand charge. Large motors, for example, use more current when they are started. If we turn on large motors in stages, we can avoid a sharp spike in required power and, in time, reduce our demand charge. Ask the utility representative whether energy management surveys are offered to their local commercial and industrial customers. Ask what recommendations are most often made in order to reduce the demand charge.

C. Ask the utility representative whether or not time of day rates have been considered by the utility company. These would give customers lower utility rates for power used during off-peak time of day.

D. Write a two-page summary of your findings and your reactions to the utility company visit. Does the company office building reflect good energy conservation practices?

ACTIVITY 3

Commercial and Industrial customers are often charged not only for the energy which they use, but also for the maximum amount of power which they draw. The purpose of this activity is to discover how your school is billed for electricity and also what kind of energy conservation measures are routinely taken. Find out if your school gets a utility bill, and whether it is billed not only for total kilowatthours of electricity consumed but also for the maximum kilowatts required at any one time during a pre-set time period. Set up an interview with the school system energy management specialist or the physical plant director and discuss what measures have been taken to reduce energy use and maximum kilowatt requirements.

During the interview, find out the answers to these questions:

A. Do the schools have higher utility bills in winter or in spring? What fuel is used most for school heating?

B. Is certain equipment operated intermittently to reduce maximum power requirements? For example, if there is air conditioning, are all the units turned on at one time?

C. How is water heated for washing and showers? Is the water heater on a time clock, and is it usually off on weekends? Would it be possible to heat water only at night when most other equipment (e.g., lights) is off?

D. How is the school heated? If a boiler is used, find out what fuel is used (e.g., oil, coal, natural gas) and how the boiler is maintained.

E. Think about the school's energy bills. Can you suggest ways in which they could be lowered?

ACTIVITY 4

The purpose of this activity is to get an estimate of the cost of electricity in Commercial and Industrial companies and about energy units used for billing.

A. Assume you operate a 50,000-square-foot clothing factory and that 60 percent of the space is used for manufacturing and office activities. In that portion of the plant, ceiling light fixtures are evenly spaced as follows: Four tube fluorescent fixtures to light every 150 to 175 square feet at an energy use rate of approximately 5 watts per square foot. Calculate the number of kilowatthours used to light manufacturing/office space each month if the plant is running only one shift each day and there are 20 working days in a month.

B. Suppose you wanted to figure out how much that amount of light would cost the company. You would need to find out what the company pays for electric power. You may find that utility pays a somewhat lower rate per kilowatthour than your parents do, but that they pay a "demand charge." This is a charge for how much power you need at any one instant and reflects the amount of capital investment the utility must make to supply the company. It differs from the energy use charge (cents per kilowatthour) which both the company and your parents pay. Often, however, large commercial and industrial users of electricity are charged a lower rate when they use more electricity. As an example, assume that the company pays 3.9 cents per kilowatthour and, in addition, a demand charge of $600 per month. Ignoring any other charges and taxes, calculate the monthly cost of lighting the manufacturing/office space in task A.

C. Natural gas utilities usually sell the gas by the hundred cubic feet or by the therm. A therm is equal to 100,000 Btu and is approximately equivalent in heating value (i.e., Btu) to that in a hundred cubic feet (usually abbreviated as CCF). The reason for this is that one cubic foot of natural gas has a heating value of approximately 1000 Btu. Call the billing department of your local gas utility and ask them what the heating value of their gas is. Also find out whether they charge by the therm or the CCF and how much each therm or CCF costs. Using the heating value given, compute the difference in Btus between a CCF and a therm.

D. Find out whether any of the schools in your school system heat with coal or oil, and find out what units are used in billing those fuels. Include this interesting information in your remarks to the class about your findings.

ACTIVITY 5

The purpose of this activity is to discover how public buildings often have special code requirements for health and safety which can add to energy use. Lighting standards have identified what lighting level is adequate for certain tasks. For example, normal office work such as reading or writing requires approximately 50 footcandles on the desk, whereas hallways need only 10 to 15 footcandles. Ventilation standards usually require at least 5 cubic feet of air flow per minute per person to circulate and filter the air in public areas. Industrial operations often produce dust or fumes that must be exhausted directly to the outside. For example, school classrooms require about 10 to 15 cubic feet per minute (abbreviated CFM) of ventilation, public rest rooms 20 to 25, and kitchens 35 CFM.

A. Study the lighting in your classroom. What is the total wattage of the lights used? How many square feet of space do you have in your classroom? Estimate how high the ceilings are. Are the walls painted in a light color? Are there windows in your classroom? Calculate the watts of power used for lighting per square foot of floor space in the room and report this to your class. Take a class survey about whether or not there is sufficient light to read and write. If the answer is no, someone from your school system or the local utility company needs to check the room with a light meter.

B. Are the windows in your room ever opened? If so, at what time of day is this usually done? How many doors are there which lead either to the outside or to the hall? Are they usually open or closed? Are there windows or louvers above the doors which can be or are usually open? Does the heating and cooling system vent air into the room? Take a class survey about adequate room ventilation. If air circulation seems inadequate, an air flow meter can be used to check.

C. Assume that you operate a movie theatre which has 20,000 square feet of floor space. The ceiling is 15 feet high. Calculate the number of minutes required to change the air, if 20 cubic feet per minute per person of ventilation are required and the seating capacity is 300 persons. Homes often experience one air change per hour.

D. Take a field trip to the supermarket at which your family shops and estimate the total wattage of lighting. Count the number of freezer compartments, and check out the number of times the front doors open and close during a specified 5- minute period. Before you start, talk to the manager and ask him to give you an estimate of the monthly electric power bill.

ACTIVITY 6

The purpose of this activity is to investigate the energy flow into and out of a manufacturing plant.

A. Call the plant manager's office at a nearby manufacturing plant. Explain to the manager's secretary about this assignment and ask for the opportunity to visit and interview a plant representative who can help you discover what energy sources enter the plant and what products and waste energy, if any, come out. An example of waste energy might be water used to cook food and then dumped while still relatively hot. Another kind of waste would be metal shavings which are not recycled.

B. Draw a diagram showing the energy inflow (e.g., electricity, oil, coal, wood, natural gas). Mark on your diagram the approximate use rate of each energy source. Add to your diagram the energy outflows (e.g., warm water, smoke or hot air, kinds of waste, and the finished product).

C. Find out how the plant is heated. They may be using waste heat for that purpose. Find out how they heat water and approximately how much they use.

D. Ask if they have an on-going energy management program and, if so, whether they have identified savings from the program.

E. Write a two-page report summarizing your findings and use it, with your diagram, to make your presentation to the class.

ENERGY-EFFICIENT STRUCTURES

USE WITH:
General Science
Physical Science

TIME:
4 class periods
(Activities 3 and 4 can be activities for the whole class, and each requires one class period.)

MATERIALS:
Large newsprint pad
Drawing paper
Several colored pens
Rulers
Protractor

Activity 3 - cardboard box, piece of posterboard, compass, clear plastic wrap, flat black paint or construction paper, thermometer, masking tape.

Activity 4 - hot plate, watch, metal stem thermometer 0-100o C, pot of water, 1/4" thick plywood or 1/2" thick fiberglass, ceramic tile, 2 plastic straws of different diameter

Worksheets (included)

Objectives

The students will:

1. Use models to learn how to maximize the comfort-conditioning of a home.
2. Observe, gather, and analyze data from the model simulations
3. Draw conclusions on the observed data.

Background Information

Among the factors influencing the energy efficiency of home design are site analysis, home orientation, configuration, envelope, space planning, ventilation, heating, cooling, lighting and appliances, domestic hot water, and waste management. These may be explained briefly as follows:

Site analysis is the recognition and use of natural elements which surround a home for energy efficiency. An example might be home siting to take advantage of wind breaks to the north.

Home Orientation would include providing a good southern exposure and intelligent distribution of windows.

Configuration design should balance the benefits of using natural lighting and minimizing perimeter wall areas. For homes with good southern exposure (i.e., solar access), the optimum configuration is generally a form elongated in the east-west direction.

Envelope considerations would include the glass and wall insulating materials selected, as well as structural design.

Space planning would locate various home activity areas appropriately. For example, the kitchen/dayrooms might share the east/south sides of the home.

Ventilation is the controlled intake of fresh air, its circulation, and exhaust.

Heating needs in Tennessee Valley homes are usually greater than cooling needs. Home heating generally consumes more energy than any other home energy use (approximately 44 percent). Heating systems which are sometimes used in the home include resistance heating (e.g., electric wall heaters), gas furnaces, wood heaters, and heat pumps. Central heating systems deliver heated air or water to all parts of the home. Heating and cooling systems are usually controlled by a thermostat.

Cooling systems in Tennessee Valley homes are almost always window or central air-conditioners which use a compressor and refrigerant to cool and dehumidify the air inside the home.

Lighting and appliances are usually powered by electricity. Exceptions include gas stoves and kerosene lamps. Well-designed insulating windows or skylights can be used to provide "daylighting". One factor to consider when purchasing appliances is the energy efficiency rating, e.g., how much work you get from a unit of energy input. The location of appliances within the living space and the ways in which they can be used and maintained for efficiency need to be considered.

Domestic hot water is the term we use for the heated water which we use for washing and bathing. As much as 25 percent of the all-electric home's electricity bill is due to domestic hot water energy consumption.

Waste management should always be a consideration in the design of large buildings. Waste management systems for homes are either non-existent or rudimentary. An insulation blanket for a water heater is a form of waste management. Another is the fresh air intake control device on the air conditioner. We will begin to see more frequent use of the air-to-air heat exchanger to preheat incoming fresh air as a waste management feature in new homes.

Procedures

1. Using the background information, introduce the eleven factors given for energy efficient homes to your students.

2. Divide your class into nine to eleven groups. Assign each group one of the following student activity sheets. They are to complete the activities and then develop a presentation to the class based on their findings. Encourage them to do further research and to make visual aids, and tell them that their job is to convince their classmates to conserve energy. You will need at least four class periods to complete this activity: 1 period for students to learn about the eleven factors for energy efficient homes; 1 for students to complete their group assignments and plan their class presentations; and 1 or 2 periods, after the groups have had a chance to do research or make visual aids, to hear presentations. Be sure to tell the groups how much time they have for their presentation (e.g., 5 minutes per group). You may wish to reserve the "CONFIGURATION" and "ENVELOPE" activities to use as activities for the whole class.

Discussion

After the class presentation by the individual groups, some effort should be made to compare design features recommended by individual groups for the same design element. For example, compare the south-facing window placement and areas specified by the Space Planning, Ventilating, and Configuration Groups. You may wish to contact TVA, your local utility, or a solar group to set up a visit to a solar home.

Resources

American Institute of Architects. Energy Conservation in Building Design. N.p.: AIA, 1974.

Mazria, E. The Passive Solar Energy Book. Emmaus, PA: Rodale Press, 1979.

Tennessee Valley Authority. Energy Saver Home Standards. N.p., TVA, [1981]

Energy-Efficient Structures

INTRODUCTION

Energy-efficient structures result from careful consideration of the following eleven design factors:

1. Site Analysis
2. Home Orientation
3. Configuration
4. Envelope
5. Space Planning
6. Ventilation
7. Heating
8. Cooling
9. Lighting and Appliances
10. Domestic Hot Water
11. Waste Management

All-electric homes in the Tennessee Valley tend to consume the following relative amounts of electricity for the consumption categories listed:

Heating	44%
Domestic hot water	22%
Cooling	12%
Lighting	10%
Refrigeration	5%
Cooking	4%
Clothes drying	3%

Each group is to complete the student activity sheet assigned to it and then develop a group presentation to be given to the rest of the class. First, you will want to meet as a group to discuss and complete your assignment and to plan your group presentation. Try to be innovative in the ways in which you present your findings. Use examples drawn from your homes and your school buildings.

Energy-Efficient Structures

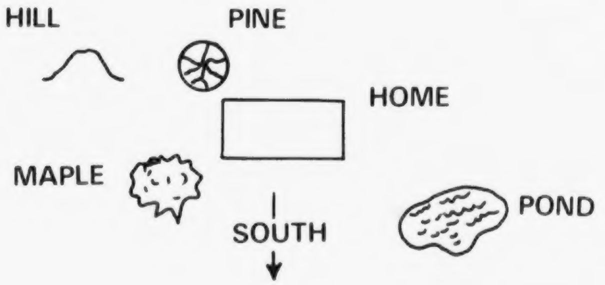
Activity 1: SITE ANALYSIS

Homes should be sited to take advantage of natural features of the terrain which offer windbreaks and summer shade. You have probably heard how one can use the sun's energy to heat a home. To benefit from the sun's heat, you do not want non-deciduous trees near the south wall of your home. Using your personal knowledge, perform the following procedure. Afterwards, at home or in the library, you may get additional information to substantiate your conclusions.

1. List terrain features which can make a home more energy efficient.

2. Explain why each feature can contribute to energy efficiency.

3. Draw a map showing compass directions, a new home, and natural features which make the new home more energy efficient. This map need not be elaborate. Here's an example:



4. Describe the new home.

5. Using a different color pen, add to your map landscaping changes you would make to improve energy efficiency.

Energy-Efficient Structures

Activity 2: HOME ORIENTATION

The sun can help to heat our homes in winter. If we use air-conditioning in summer, the sun can increase our energy use and bills unless we provide sun controls. Sun controls which might be used include shade (deciduous) trees, roof overhangs, windows blinds and drapes, and thermal insulation. If south-facing glass area is limited to approximately 10 percent of the comfort-conditioned living space area in a house in the Tennessee Valley, there should be more winter energy savings than summer losses (i.e., a net decrease in annual energy used for heating and cooling). Using your personal knowledge, perform the following procedure. Afterwards, at home or in the library, you may get additional information to substantiate your conclusions.

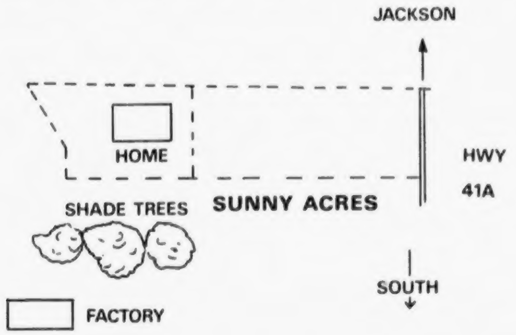
1. List the uses of windows.

2. Think about the position of the sun relative to your location. Describe summer sun positions at daybreak, noon, and sunset. Describe winter sun positions at these same times.

3. If you were a real estate developer and you wished to develop a subdivision in which the homes are designed to maximize energy conservation, you would have to orient the houses properly. Draw a simple aerial map showing the compass directions and the meadows and hills where you will construct the "Sunny Acres" Subdivision. Draw the nearest road which leads into town.

4. Now, select the lot on which you will build your own new home and plan the access streets which will lead to the town road.

5. Draw a top view of your new home on the map. NOTE: Your map may look something like this one:



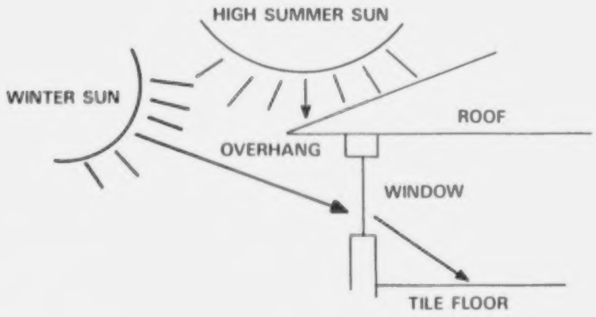
6. Mindful of your household activities and the wish to benefit from the sun, indicate on separate sketches representions of the four walls, the doors, and windows of your new home.

7. How will you prevent the summer sun from entering the windows? How will you prevent heat loss through the windows during winter? Identify any exceptions to the rules you establish.

Energy-Efficient Structures

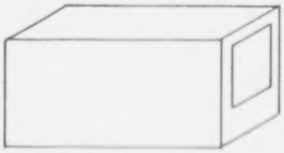
Activity 3: CONFIGURATION*

People have long been aware of the heating effects of the sun. Utilizing the heat in the winter and avoiding it in the summer helps to cut down on heating and cooling costs. Structures can be designed to conserve energy in both the winter and the summer. This investigation considers the manipulation of a "roof overhang" to illustrate a shading device used to promote the natural cooling of a house.



Perform the following procedure and log your data on the data sheet. Refer to the drawings provided for guidance. Be prepared to demonstrate this experimental procedure during the class presentation.

1. Cut a hole in one side of the box.

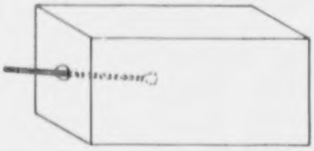


2. Paint all the inside surfaces of the box flat black (or cover them with black construction paper). Cut white poster board for the roof longer than necessary to make sure the roof covers the entire box and is extended to give complete shade of the window.

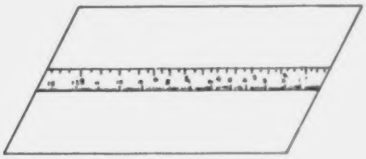
3. Use the plastic wrap to cover and seal the open side of the box. Use masking tape, if necessary, around the edges. Make sure the window is placed closer to the top of the box than it is to the ground.

*This activity may be used with the whole class.

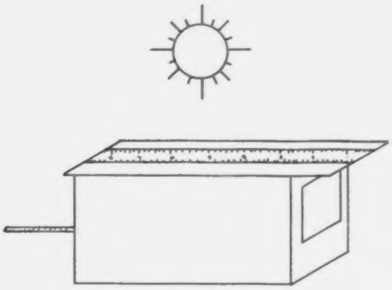
4. Make a small hole toward the back of the box. The hole should be large enough to insert a thermometer through it. Make sure the bulb of the thermometer is measuring the air temperature in the box. It should not be in direct sunlight.



5. Tape a ruler along the side of the "roof" piece. This will allow you to easily measure the amount of roof overhang.



6. Set this "model" house up outside in the direct sunshine around noon. The window should be facing south.



7. Place the roof so that there is 100 percent shadow on the window. Wait about 5 minutes until the temperature has stabilized and record the temperature in the box. Also record the air temperature outside the box.

8. Gradually move the "roof" 2 cm at a time. Each time record the temperature after it stabilizes. Do this until you have measured the temperature of the box when its window is 100 percent in the sun.

9. Record the amount of roof overhang and the measured temperatures on the table below.

10. Estimate the width of roof overhang needed in the Tennessee Valley by sketching to scale the south wall (assume it is all window), and determining the roof overhang needed when the noon sun is 75 degrees above the horizon. For this exercise, assume the roof is a flat one as in the model.

DATA TABLE

Amount of roof overhang (in cm):		Temp (°C)
all of the window	________ cm	________
3/4 of the window	________ cm	________
1/2 of the window	________ cm	________
1/4 of the window	________ cm	________
none of the window	________ cm	________

Discussion Questions

1. Would a roof overhang be important on north-facing windows? Would your answer change, if you were living in Australia?
2. From the estimate you made of roof overhang needed, what can you deduce about the placement of deciduous shade trees to the south?
3. Think about the way the sun seems to move from east to west during a day. What can you say about shade tree placement to diminish west sun?

Energy-Efficient Structures

Activity 4: ENVELOPE*

It is important to "weatherproof" a home, e.g., to insulate, caulk, and weatherstrip doors and windows. Insulation is any material that slows the movement of heat from one place to another. It slows the flow of heat entering the house during the summer. It slows the flow of heat leaving the house in the winter. The effectiveness of insulation in slowing the flow of heat is measured in resistance or "R-value." The higher the R-value, the better the insulating potential. Both thickness and composition are important factors in insulating effectiveness. For example, fluffy fibrous insulations should not be compressed before or during installation. In this experiment you will compare the effects of both thickness and composition on insulating capability. CAUTION! This experiment should be done under the teacher's supervision.

1. If the hot plate has a warm setting, use it.

2. Monitor and log the stabilized hot plate temperature.

3. Measure and log the thickness of the ceramic tile.
   Lay it on the hot plate.

4. Measure and log the tile's top surface temperature each minute for five minutes. Now take readings every two minutes for ten minutes. Take a final reading five minutes later. Log all temperatures on the data table. Remove the tile from the hot plate using heat-protective gloves.

5. Measure and record the thickness of the plywood or fibrous insulation batt. Lay it on the hot plate. If you're using the fiberglass, use gloves.

6. Measure and log the insulation's top surface temperature after 3, 6, 9, 12, and 15 minutes.

7. As a home assignment, plot the top surface temperatures of the tile and insulation as a function of time. Which temperature history rises faster?

8. Place the pot of water on the hot plate and make it as hot as possible. While the water is heating, make an insulating sheath by inserting the smaller diameter straw inside the other one, folding both straws back at the midpoint and using the pressure sensitive tape to hold the ends together.

*This activity may be used with the whole class.

9. Measure and log the temperature of the water.

10. Allow the thermometer to cool (by putting the end in cool water) and insert the thermometer stem into one of the open ends of the straws. Use a watch to time how long it takes the thermometer to measure the water's temperature. Observe whether or not it takes longer than it did to do the same thing in step 6.

11. Turn off hot plate.

12. Explain why the insulating sheath you made of soda straws worked.

DATA TABLE

Stabilized Hot Plate Temperature ______________°C

Ceramic tile:
Thickness ____________ cm

Elapsed Time (minutes)	Temperature (°C)
1	
2	
3	
4	
5	
7	
9	
11	
13	
15	
20	

Plywood:
Thickness _____________

Elapsed Time (minutes)	Temperature (°C)
1	
2	
3	
4	
5	
7	
9	
11	
13	
15	
20	

Insulation:
Thickness ___________ cm

Elasped Time (minutes)	Temperatures (°C)
3	_______________
6	_______________
9	_______________
12	_______________
15	_______________

Water:
Water Temperature ____________ °C
Time required to reach water temperature (above) when insulating sheath is used: ________________ minutes.

Discussion Questions

1. How does the tile affect the surface temperature of the hot plate? Would tile be considered as insulation? Why?

2. How would the thickness of the insulation affect the insulating ability?

3. What is the difference between the tile and soda straws in terms of insulation?

Energy-Efficient Structures

Activity 5: SPACE PLANNING

The sun's warmth and light can make a good house even better. Think about your own family's activities and then design the interior room arrangement of an energy-efficient, passive solar home. In so doing, perform the following procedure. Afterwards, at home or in the library, you may wish to get additional information.

1. Where are family members in the morning, at mid-day, in the evening, at night? What kind of space and comfort-conditioning do they need at these times?

2. Draw a map showing compass directions, and a top-view of a new home. Generally lay out the room arrangement; locate doors and windows, and then partition the space into rooms and storage space. Don't forget the need for emergency egress and traffic flow.

3. Suggest construction materials (e.g., wood paneling, brick, tile), wall colors (e.g., light, dark, warm, cool), lighting.

Energy-Efficient Structures

Activity 6: VENTILATION

Home ventilation is the controlled intake of fresh air, its circulation, and its exhaust. Average home construction can result in inside air changing one time each hour. Tight construction can reduce this to perhaps one-half an air change per hour. Fresh air enters the house through windows, doors, intake louvers on comfort-conditioning equipment, and infiltration or leakage. Many new homes use kitchen or bathroom exhaust fans which tend to induce a flow of outside air by reducing inside pressure slightly. Outside air is sometimes supplied to the fireplace grate. Vents are always provided to reduce humidity in attic or crawl spaces.

Using your personal knowledge, perform the following procedure. Afterwards, at home or in the library, you may get additional information to substantiate your statements.

1. Draw the floorplan of a new house to approximate scale, noting on your drawing the compass directions and the length, width, and height of your home. (You need not show inside room partitioning unless the ceiling height in the house is not uniform). Calculate amount of floorspace in the home and its total air volume. Relate the air volume to anticipated air changes.

2. Make a fairly complete list of the likely places where air leakage may occur. Discuss remedies for each condition.

3. Discuss some kinds of windows or glass doors you have seen and rate them from most to least likely to cause air leakage.

4. Where might fixed glass (i.e., windows that don't open) be used effectively? Look up in the dictionary the word "clerestory," noting both its meaning and pronounciation. Clerestory windows are often used in conjunction with a "cathedral" ceiling. They do one thing exceptionally well. Can you think what that might be?

5. Describe what is meant by "cross-ventilation."

Energy-Efficient Structures

Activity 7: HEATING

Heating is very important in Tennessee Valley homes because we have many cold winter days. From your personal knowledge perform the following procedure. Afterwards, at home or in the library, you will need to find information to substantiate your choice. If you call and request an interview at his or her convenience, you may get a fast overview of heating system types by talking to a heating contractor.

1. Using the following outline, briefly describe heating systems used and their advantages and disadvantages.

    A. Room Heaters
        a. electric resistance
        b. wood
        c. gas
        d. oil
        e. coal
        f. solar

    B. Central Systems (circulating heated water or warm air)
        a. electric resistance
        b. heat pump
        c. gas
        d. oil
        e. coal
        f. wood

2. Insofar as you can, discuss the relative cost of these systems, their efficiency, and their maintenance requirements.

3. Discuss the likely availability and cost of fuels during the lifetime of these systems.

4. Select a heating system for a new Tennessee Valley home.

Energy-Efficient Structures

Activity 8: COOLING

New homes in the Tennessee Valley often have a window or a central air conditioner which uses a compressor and refrigerant to cool and dehumidify inside air. Using your personal knowledge, perform the following procedure. Afterwards, at home or in the library, you will need to get additional information to substantiate your choice (you may want to talk with a cooling systems salesman for more information).

1. How would you describe the Tennessee Valley's summer climate? Does it vary widely from east to west? If so, why? Does it vary widely from north to south?

2. Discuss what you know about relative humidity and compare the relative humidity in a steam bath or sauna, a baseball game, and a cave. What happens when warm, moist air is suddenly cooled? What happens when you go outside on a cool, breezy day with a wet head?

3. Air conditioners and heaters are usually controlled by thermostats. Do you know how your parents control their cooling system? Can you agree on daily settings for cooling system control? If no one will be home, is it economical to leave your air conditioner running while you are away?

4. What do you know about heat pumps? They can be thought of as reversible air conditioners, supplying cool in summer and heat in winter. Because they use refrigerants, heat pumps can absorb heat from cool air in winter effectively. (You won't need to select a separate air conditioner, if the "Heating" group selects a heat pump.)

5. You will want to compare the efficiency of different brands of air conditioners. To do this, you will need to compare their Energy Efficiency Ratios (EER). The Energy Efficiency Ratio is defined as the rate at which heat is removed from the surroundings, usually expressed as British thermal units per hour, divided by the rate of energy input power in watts required to operate the machine and associated blowers. Select a group member to call one or two appliance stores tonight to find out what typical EERs are (note brand name also) and also what the expected annual operating cost might be (they may not know this).

6. You don't want to have more air conditioner than is needed. It is best to have one that runs a lot and, in doing so, removes more humidity. You must make sure the appliance dealers take the energy efficiency of your house into account when sizing your cooling system. Air conditioners are often rated in tons. A ton of air-conditioning is usually expressed as 12,000 British thermal units per hour. A window air conditioner may range in size from 3/4 ton to two tons. Find out what size was used in the typical air conditioned house which is 15 to 20 years old. Find out what size was used in a newly completed house of about the same size.

7. Select your cooling system from among those you have researched.

Energy-Efficient Structures

Activity 9: LIGHTING AND APPLIANCES

"Lighting and Miscellaneous Appliances" account for about 10 percent of the energy consumption in an average Tennessee Valley all-electric home. Typically the big three users are heating (44 percent), hot water (22 percent), and cooling (12 percent). Lighting consumes about 10 percent of the electricity used in a typical home. The lesser three are refrigeration (5 percent), cooking (4 percent), and clothes drying (3 percent). Your job is to select a new home lighting system, explore ways to select energy efficient appliances, and make suggestions for managing home energy use wisely. Perform the following procedure. Afterwards, at home or in the library, you may get additional information to substantiate your conclusions.

1. In your new home you want to avoid sharp changes in light intensity. Yet you need good light directed on the things you need to use, e.g., for reading, at your work bench, on the kitchen counter. Fluorescent lighting tends to be cooler than incandescent lighting and about twice as efficient. The term "cooler" does double duty, i.e., cooler in terms of temperature and in having a cooling effect on surrounding surfaces. Some incandescent lighting mixed in produces a warmer, cheery look. With these things in mind, and supplying personal knowledge and opinion, design a lighting system for your new home. Draw a sketch showing light fixture placement in the kitchen, the living room, and a bedroom. Try to decide what light-related qualities wall and floor coverings should have. Don't forget to consider window placement and how it will affect lighting needs.

2. Here are some estimates of the annual use of various appliances. The numbers are kilowatthours.

range with oven	1152	clothes dryer	1000
microwave oven	300	clothes washer	624
frying pan	190	dishwasher	1560
coffee maker	110	hand iron	150
toaster	40	color tv, solid state	440
clock	18	b&w tv, solid state	120
mixer	10	radio/phonograph	110
refrigerator/freezer, 17 cu.ft., 2 dr, auto defrost	1200	vacuum cleaner	50
attic fan	300	dehumidifier	400
ceiling fan	130	electric blanket	150

   Select one appliance that uses a lot of energy and find out (1) if annual average energy use for different brands is available, (2) how three brands with the same features compare in energy consumption, and (3) if the number given in this table is reasonably accurate.

3. For the appliances selected, list some measures which, if followed, will reduce energy consumption.

Activity 10: DOMESTIC HOT WATER

The average Tennessee Valley family uses approximately 5400 kilowatthours of electricity in a year to heat water. Using your personal knowledge, perform the following procedure. Afterwards, at home or in the library, you will need to get additional information to substantiate your conclusions.

1. Here are some ways to reduce the energy consumed by heating water:

   a. Fix leaking faucets.
   b. Use shower flow restrictors.
   c. Insulate your water heater.
   d. Set the water heater aquastat at a lower temperature, if possible.
   e. Take showers instead of baths.
   f. Take cooler showers and make them short.
   g. Try washing clothes with cold water.

   Discuss there with other members of your group and with your parents. Check your own home for compliance.

2. List the advantages and disadvantages of the following kinds of water heaters (if you do not know how they work, find out):

   electric water heater
   gas water heater
   heat pump water heater
   garden hose in the sun
   solar water heater

3. If an electric water heater uses 5,400 kilowatthours annually and a natural gas water heater uses 25,000 cubic feet of natural gas, determine how much each will cost to run annually. Your local gas and electric utilities can help you.

4. Select a water heater for your new home and explain your choice.

Energy-Efficient Structures

Activity 11: WASTE MANAGEMENT

This is a difficult subject because, in homes, while energy is often conserved, once used, it is not recovered. Think about the subject for a while. How can you recover energy once it is used and distributed? Hint: Where does energy go once it is used? FURTHER HINT: Three words which explain a lot are preheating, heat exchanger, and recycling.

From your personal knowledge, answer the following questions. Afterwards, at home or in the library, you need to get additional information for your presentation.

1. There are a few uses of preheating in the home. For example, a passive solar water heater which preheats the water. Another example is taking frozen food from the freezer and letting it thaw on its own before cooking it. This saves cooking time and saves energy. Can you think of any other examples of preheating?

2. A heat exchanger is a device by which heat is transferred from one material or fluid to another. For example, an automobile radiator is a heat exchanger by which a water/antifreeze mixture, used to cool the engine, loses heat to outside air forced through radiator passages. In this example, the water is cooled for re-use by outside air. However, most of the heat picked up by the outside air is not used. How does the automobile use some of it?

3. Are there heat exchangers in the house? How does the air conditioner cool household air? How does the heat pump heat inside air? What other heat exchange applications in the home can you list?

4. List materials used in or around the home which can be recycled. List materials found in your garbage can which can be recycled.

5. Would you recommend any waste management systems for your new home? Estimate their costs by using the following scale: (a) How would the systems compare in cost to a central heating and cooling system? (b) How would they compare in cost to a refrigerator? (c) How would they compare in cost to a water heater?

THE ELECTRIC HOOKUP

USE WITH:
General Science
Physics

TIME:
2 class periods over a 2 week span

MATERIALS:
Worksheets (included)

Objectives

The students will:

1. Determine the wattage of various household appliances.
2. Calculate the number of kilowatthours used by appliances.
3. Identify need to limit the use of appliances to conserve energy.
4. Identify costs/kWh of appliance.

Background Information

If you were to list all the energy-using appliances and equipment in your home, you would see why it is estimated that a well-equipped home consumes as much as 35,000,000 Btus (British thermal units) of energy each year to operate appliances and equipment. Much of this energy is wasted and offers a great opportunity for energy conservation.

The first step toward conservation is to gain a better understanding of the energy consumption of each appliance or piece of equipment.

The wattage is an indicator of the kilowatthours of energy used per hour of operation of the appliance. It requires 1 kilowatthour per hour of operation for 1,000 watts. For example, a mixer draws 127 watts. This 127 watts divided by 1000 watts/kilowatthour of operation equals 0.127 kilowatthour. If we use the mixer for only 6 minutes, we have only used 0.0127 kilowatthour of energy.

Procedure

1. Distribute Activity 1 worksheet. Have students bring in wattage ratings from various appliances around the house. Ask each student to choose appliances that would show relative energy use: one that requires heat, one that produces music or sound, and one that produces motion (contains a motor). Caution students not to move large appliances by themselves to obtain wattage ratings. Have them seek permission and aid from parents to locate wattage rating information. (Check the owner's manuals before moving appliances.) Use appliances in the school as examples. Students may be assigned different equipment to ensure a wide range and thorough investigation of household appliances. Answers in terms of kilowatthours of energy required may be expanded to annual use by determining daily or weekly use and multiplying. If you prefer, use the Appliance Energy Use table provided.

2. Pass out "How to Read Your Meter" handout. Tell students to record the meter reading at home daily for two weeks, and then to bring in an old utility bill with the data they will have accumulated from the meter.

   Review the information recorded on their utility bills. Then, have each student figure the charge per kilowatthour by dividing the electric service charge by the number of kilowatthours used in their homes for that month's bill.

   Price per kilowatt (kWh) hour = $____________

3. Have each student relate the amount spent on one month's bill to something that is pertinent to his/her own life. For example, car payments, cost of music albums, stereo equipment, school books, etc. Solicit several examples from the class.

4. Use "Making Choices" after the preceding steps to see if the students are willing to change their attitudes and possibly their lifestyles to conserve energy.

Discussion

1. Discuss what negative aspects or feelings students are having about conserving electrical energy. (By now, the benefits should be obvious--saving money and resources.) After all, conservation often takes self-discipline, development of routine habits, imposing rules upon oneself, lifestyle changes, etc. Oftentimes these things are not fun or easy for people to accept. What ways can the students think of to motivate themselves and others to conserve? NOTE: This question may be most appropriate after "Making Choices" activity.

2. Discuss practical ways that students can improve electric energy conservation in their own homes. Ask, "In what area is your family conserving energy best?" (for example, turning off lights); "In what area is your family not conserving energy well?" (for example, leaving the TV on while no one is watching).

ACTIVITY #1

WATTAGE RATINGS

Appliance: ____________________

____________ watts / 1,000 ____watts______ = ____________ kWh
kWh per hour
of operation

Appliance: ____________________
____________ watts / 1,000 ____watts______ = ____________ kWh
kWh per hour
of operation

Appliance: ____________________
watts / 1,000 ____watts______ = ____________ kWh
kWh per hour
of operation

Appliance: ____________________
watts / 1,000 ____watts______ = ____________ kWh
kWh per hour
of operation

Using the table below you can see what the appliances you checked consume in equivalents of oil or coal.

ELECTRICAL APPLIANCE ENERGY TABLE

Appliance Wattage Rating	Kilowatthours of Energy Used per Hour	Ounces of Oil Burned per Hour	Ounces of Coal Burned per Hour
10	0.01	0.01	0.13
25	0.025	0.025	0.33
40	0.04	0.4	0.5
60	0.06	0.6	0.8
100	0.1	1	1.33
150	0.15	1.5	2
200	0.2	2	2.66
300	0.3	3	4
500	0.5	5	6.66
750	0.75	7.5	10
1000	1	10	13.33
1500	1.5	15	20
2000	2	20	26.66
5000	5	50	66.66
10000	10	100	133.33

APPLIANCE ENERGY USE

Think about burning ten 100 watt light bulbs for one hour. That's the amount of electricity it takes to make one kilowatthour (kWh). Just as you pay for gallons of gas, quarts of milk, and loaves of bread, you pay for kilowatthours of electricity.

The chart below will tell you the average number of kilowatthours of electricity that various appliances use.* If you're interested in how much it costs you to operate one of these appliances for a month or a year, contact your local utilities company.

APPLIANCE	AVERAGE KWH USED	
Kitchen	Annually	Monthly
Range w/self-cleaning oven	1224	102
Range w/oven	1152	96
Microwave oven	300	25
Frying pan	190	16
Coffee maker	110	9
Toaster	40	3
Mixer	10	1
Food disposer	30	3
Dishwasher	1560**	130
Refrigerator/freezer 16-25 cu. ft side-by-side model, automatic defrost	2160	180
Refrigerator/freezer 14 cu. ft. automatic defrost	1800	150
Refrigerator/freezer 14 cu. ft. manual defrost	1200	100
Refrigerator/freezer 17 cu. ft., 2 door high efficiency, automatic defrost	1200	100
Freezer, 15 cu. ft. automatic defrost	1800	150
Freezer, 15 cu. ft. manual defrost	1200	100

APPLIANCE	AVERAGE KWH USED	
Laundry	**Annually**	**Monthly**
Clothes dryer	1000	83
Clothes washer	624**	52
Hand iron	150	13
Other		
Quick recovery water heater	5400***	450
Vacuum cleaner	50	4
Clock	18	2
Toothbrush	0.5	0.04

APPLIANCE	AVERAGE KWH USED	
Entertainment	**Annually**	**Monthly**
Color T.V.	660	55
Tube Type	440	37
Solid State	440	37
B&W TV		
Tube Type	350	29
Solid State	120	10
Radio/phonograph	110	9
Comfort		
Electric furnace	13200*****	(Seasonal)
Heat Pump	6600****	(Seasonal)
Air conditioning Central, per ton	1500*****	(Seasonal)
Air conditioning Room, one ton	1500	(Seasonal)
Dehumidifier	400	33
Electric blanket	150	(Seasonal)
Attic fan	300	(Seasonal)
Ceiling fan	130*	(Seasonal)

* These figures are averages and will vary depending on your habits and lifestyle.

** Includes kWh for heating water used by appliance.

*** This value accounts for all hot water usage, including dish washing and clothes washing.

**** Heat only.

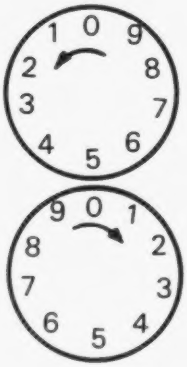
***** Based on 1,500 sq ft. house insulated to meet TVA standards for energy efficiency. If your house does not meet these standards it may use considerably more electricity during the heating and cooling seasons.

ACTIVITY #2

HOW TO READ YOUR METER

In order to read your meter you must read from left to right. Also, to read your meter, you must determine which way the hands are turning on each dial.

Example:

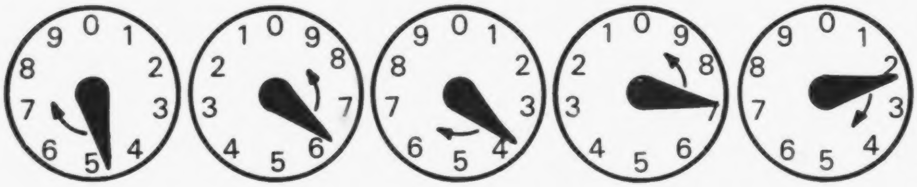


The 1 is on the left side of the dial. This would indicate the hand is turning counter-clockwise.

Here the 1 is on the right side of the dial indicating the hand turns clockwise.

Write down the number each hand has passed. This may not be the number nearest the hand. For instance, if the hand has passed the 4 and is almost to the 5, you still read it as 4. Write down the numbers in the same order as you read the dials, from left to right.

In the example given, your present reading is 46372. Next, you subtract that number from your last reading which is 45109. This will give you the number of kilowatt hours (kWh) used).



Note: Some of the hands turn right and some turn left.

46372 present
45109 last
1263 kWh used

That is all there is to reading a meter, with one exception. If a hand points straight at a number and you do not know if it has passed or not, then do this. Look at the dial to the right, has it passed zero?

To analyze your electric use, read and record your meter daily for about two weeks, at approximately the same time each day. Use the chart below.

DAILY USE OF ELECTRICITY IN MY HOME

DATE	TIME	READING	KILOWATT HOURS USED DAILY	COST kWh X	*
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					

* Current kWh cost; e.g. $0.045 per hour in 1985

ACTIVITY #3

MAKING CHOICES

Assume that the government has announced that, because of an energy crisis, energy usage will be rationed. According to a new regulation, homeowners will be permitted to own and use no more than 12 electrical items other than lighting and heating/air conditioning. Listed below is a variety of items which use electricity that are often found in American homes. Choose the 12 items which you feel would be most essential to you and rank them from 1 to 12 (1 being the most important, 12 the least). Be prepared to defend your choices.

____ Television
____ Automatic coffee pot
____ Dishwasher
____ Blender
____ Electric mixer
____ Electric shaver
____ Electric clock
____ Curlers/curling iron
____ Electric typewriter
____ Microwave oven
____ Telephone
____ Electric blanket
____ Garbage disposal
____ Refrigerator
____ Washer/dryer
____ Food processor
____ Electric knife
____ Toaster
______ Electric can opener
______ Makeup mirror
______ Waffle iron
______ Vacuum cleaner
______ Fan
______ Sewing machine
______ Water heater
______ Stereo
______ Electric stove
______ Toaster oven
______ Freezer
______ Computer
______ VCR/VHS
______ Iron
______ Griddle
______ Crock pot
______ Power tools
______ Hair dryer

RECYCLING

USE WITH:
General Science
Physical Science

TIME:
3-4 class periods

MATERIALS:
Activity sign-up sheet (included)
Worksheet with instructions for making paper (Activity 2) (included)

Objectives

The student will:
1. Discover the energy savings from which Americans could benefit if they became involved in recycling.
2. Learn the process of recycling.

Background Information

Our society is considered a "throw-away" society. We consume natural resources at an alarming rate for products such as paper, aluminum, oil, glass, plastic, and various metals. Recycling reduces waste and the cost of producing these materials for consumers.

Paper is one of the most popular recyclable materials. Each year, the average American reads the equivalent of more than 100 pounds of paper. In this country, 25 percent of the newsprint, 40 percent of used corrugated material, and 20 percent of high-grade waste paper is recycled. Newsprint makes up about 10 percent of all urban solid waste. For each ton of this discarded newsprint that is reclaimed, the equivalent of 17 trees can be used for other purposes. Recycling paper also reduces the volume of solid waste disposed of in already overburdened landfills.

Aluminum is made primarily from imported bauxite. Recycling aluminum requires less than 5 percent of the energy used to process aluminum originally. The U.S. Bureau of Mines estimates that $5 billion dollars worth of recyclable aluminum is discarded in the U.S. every year. Also, aluminum waste causes a major problem in landfills because it does not deteriorate. Today, recycling centers are purchasing waste aluminum from citizens in an attempt to impact this growing problem. For the recycling collection point nearest you, call the Reynolds Aluminum Recycling toll free number (1-800-228-2525) or look in the yellow pages under Recycling Centers.

Another readily recycled material is the used oil drained from crankcases of automobiles. A small amount of oil can contaminate drinking and surface water, rendering it unfit for humans and wildlife. It takes 1/42 the amount of crude oil to make lubricating oil if recycled oil is used. Yet it is estimated that 50 percent of recyclable oil is lost through dumping or incineration.

Glass accounts for at least 10 percent of municipal solid waste, yet it is one of the easiest materials to recycle.

Plastic recycling is just beginning to be feasible. Plastics also pose a problem in landfills since they do not deteriorate.

A growing concern over the dwindling supply of natural resources has increased emphasis on and interest in recycling. This unit is designed to increase student awareness about this national conservation effort.

Procedure

1. Using the background information, introduce the concept of recycling to the class.

2. Ask students to help generate a list of reasons why they think it is important for people to recycle. Leave this list in a visible place where students can refer to it.

Recycling:

- * reduces consumption of dwindling supplies of natural resources.
- * conserves energy.
- * reduces build-up of waste already a problem in overburdened landfills.
- * reduces air, water, and soil pollution.
- * keeps citizen awareness of of environmental problems alive because it requires citizens' direct participation.

3. Have each student sign up for one activity on the ACTIVITY SIGN UP SHEET. There are 15 activities altogether; however, most activities are designed to be completed by one student or a team of 2 students each. Therefore, there are enough projects to serve 30 students, if necessary. Give students several weeks to complete their projects. Several students will need to schedule class time to complete their assignment. For example, project No. 6 requires students to perform a commercial on recycling for the class.

Discussion

1. Ask students if they think recycling really works.

2. What would happen if we did not recycle?

3. What role in the environmental pollution problem does recycling play?

4. Has the information learned in this activity made students consider changing attitudes or behavior regarding recycling?

Resources

Alabama Environmental Quality Association. Recycling: Unburied Treasure. Montgomery: EnviroSouth, Inc., 1981.

________. The Recyclopedia. Montgomery: EnviroSouth, Inc., 1982.

ACTIVITY SIGN-UP SHEET

RECYCLING ACTIVITY

STUDENT NAMES	
____________ ____________	1. Design a game to teach people about recycling.
____________ ____________	2. Make fresh paper from used newspaper, then write a list of facts about the paper making and milling industry on your homemade paper to hang on your classroom wall. How many trees does it take to make fresh paper? Ask your teacher for the instruction sheet on how to make paper.
____________ ____________	3. Put together a short brochure on where to find recycling centers in your community, and what their rules and conditions are for submitting recyclable materials. Give a copy to each student in your class.
____________ ____________	4. Set up a method for recycling paper, glass, and aluminum at your home. Involve your family for a two-week trial period. Write at least a two-page report on the program's effectiveness: problems you had, how much material you collected, convenience of continuing, etc.
____________ ____________	5. Set up a paper recycling program for your classroom. After a two-week trial, write at least a two-page report on the effectiveness of your program: what problems did you encounter, how much material and money did you collect, how much would you collect if you continued the program for a year, etc.
____________ ____________	6. Create a commercial publicizing the need for recycling. Use of music, costumes, or other creative media is encouraged. Schedule with your teacher to perform the commercial for the class.
____________ ____________	7. Plant a trash garden by getting permission to dig up a small plot of land on the school ground (or at home); then bury several kinds of trash. Have pieces that represent trash made of: paper, glass, aluminum, plastic, oil, metal, etc. After a few months, dig up the trash and make a presentation to the class on your findings.
____________ ____________	8. Design a comic book on recycling.
____________ ____________	9. After some investigative research, write a newspaper article on your community involvement (or lack of involvement) in recycling.

10. Develop a coloring book on recycling for

11. Do a community photography study of trash and recycling. Mount your photos on a board or in a book. Caption each one.

12. Arrange with your school custodian not to do any classroom cleaning for one week. Write a report on what happens and record how students feel about the room at the end of the week, what materials have accumulated, and how much of the waste can be recycled.

13. Research where used car oil goes in your community. Trace where it can travel from the time you buy it until it completes a cycle. Use geologic time if you have to. Using an illustrated chart you design, present your findings to the class.

14. Research the cycle of aluminum cans. Trace where the aluminum travels from the time you purchase it in the form of cans from the store until it completes a cycle. Using an illustrated chart you design, make a presentation on your findings to the class.

15. Create your own recycling project.

INSTRUCTIONS FOR MAKING PAPER
(to be used in Activity 2)

Materials

An electric blender

Several wooden frames with screen (5 x 7" or 8 x 10")

Stack of old newspapers

Several glass baking dishes (14-1/2 x 10 x 2-1/2")

Several pairs of white desk blotters

Several wooden spoons

Paper toweling

Electric iron

Rolling pin (optional)

Procedure

Tear paper trash into small strips, and place in blender until 1/3 full. Add water until 2/3 full. Blend 3 to 5 seconds. Add more paper. Pour "mush" mixture into baking dish. Add water to bring mixture level to 1 inch depth in pan. Mix well. Taking framed screen, spoon mixture onto it evenly. Hold screen over pan, allowing excess moisture to drip off. Place the long edge of screen onto one of the blotters and flip it over. Use paper toweling to blot excess moisture seeping through screen. Remove paper and blotter from screen carefully. Place second blotter over first blotter, sandwiching "paper" between. Place the "blotter sandwich" onto a pad of newspaper. With the iron setting on wool, iron the blotters. Flip and iron the second side. Carefully peel blotter off top. If paper is not dry, iron it. (A rolling pin may be used to flatten paper before ironing.)

CUTTING COST WITH CLOTHING

USE WITH:
General Science
Home Economics

TIME:
3-4 class periods

MATERIALS:
Tables and chairs
3 lamps
Fabric swatches
Ice cubes
Hangers
Clothes pins
Ruler
3 watches
Charts
T-shirts

Objectives

The students will:

1. Learn about the insulation ability of various fabrics.
2. Learn how color relates to effectiveness of the fabric or garment.
3. Use various fabrics for comfort in different climates.

Background Information

In today's energy-conscious society, offices, restaurants, and homes are striving to set thermostats at more efficient levels. Often this makes the clothing you wear essential to your comfort. The cooler the weather, the more clothing required, and conversely, the warmer the weather, the less clothing required.

The kind of fabric also affects its ability to cool or warm us. The absorbency of a fabric (its ability to absorb or repel water), the amount of air space within the weave, and its color all have a major effect on keeping us warm when it's cold and raining or cool when hot weather causes us to perspire. The key to the effective use of clothing as an energy conservation tool is to recognize the importance of maintaining a balance for constant body temperature. Appropriate to the season, one chooses attractive insulation for the body which creates a still air space around the body at a comfortable temperature.

Procedures

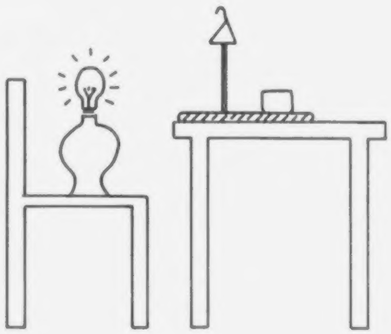
1. Using the background information, introduce to the class the idea that clothing can have a significant effect on conserving energy.

2. Divide the class into 3 groups. Tell them their task is to test the ability of certain fabrics to insulate. Assign each group one of the following fabric categories:

   Protein fibers: fabrics made of animal products such as wool or silk.
   Cellulose fibers: fabrics made of plant products such as cotton, linen, ramie, and rayon.
   Thermoplastics: fabrics made of petroleum or other products such as acrylics, nylon, acetate, and polyester.

3. Give each group a lamp with a 60-watt bulb, a clothes hanger, a few clothes pins, a bucket of large ice cubes, a towel or two, a watch, a copy of the chart (attached) for recording data, and several samples of cloth from their assigned category.

4. Have them set up the equipment according to the diagram below.



There should be approximately 15 cm between the light bulb and the fabric sample, and 15 cm between the ice and the fabric sample. Also, the light bulb, the cloth, and the ice cube should be at approximately the same height. Students can hold the hanger in the proper position or hang it from something. Caution students not to touch the uncovered light bulb or trip over the cord.

5. Have each group first record on the Fabric Insulation Chart how long it takes an ice cube to melt with no heat applied, and then with heat but no fabric insulation, before they start testing the fabric.

6. Have the students time how long it takes the ice cubes to melt as each kind of fabric acts as an insulator between the heat source (the lamp) and the cold source (the ice cube). Record the data on the chart.

7. Ask the students to answer the following questions:

   Which fabrics delayed the ice melting the most? the least?

   Which fabrics would you use to insulate your body if you wanted to keep it warm? cool? (NOTE: On warm days your body could be considered the cool source and on cold days your body could be considered the warm source.)

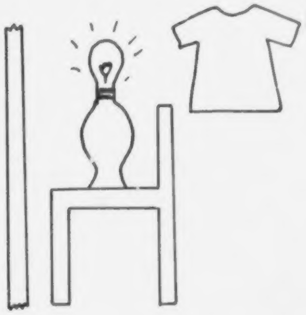
8. Pick up all equipment. Compare data collected by the entire class.

9. On another day, introduce the idea that color affects the ability of fabric to reflect or absorb energy.

10. Have each student bring a cotton T-shirt from home. Sort them into colors, i.e. dark to light, and reds with reds, greens with greens, etc.

11. Perform the following demonstration/experiment in a dark room.

12. Set up a lamp with a 60-watt bulb approximately 1 foot away Hold a T-shirt approximately 1 foot away from the lamp. There should be a circular reflection cast on the wall.



13. Have someone measure the diameters of the reflections made by different colors and record the data on the Fabric Reflection Chart.

14. Compare how the reflection's diameter changes with different colors of T-shirts. (The bigger the diameter, the more light is reflected.) What can the students conclude about how color affects fabric and its ability to reflect or absorb energy? Which colors would be warmer/cooler on a hot/cold day?

15. Have each student write a two-page report on which clothes they would wear on a day hike at the North Pole or in the Sahara Desert, and why.

Discussion

1. Ask students if they feel they have become better consumers because of what they have learned. What will they do differently from now on when purchasing clothes?

2. How can this information help students conserve energy in their homes?

FABRIC INSULATION CHART

FABRIC TYPE	TIME START	TIME STOP	TOTAL TIME

Melting time, no heat applied: ____________________ minutes

Melting time, no fabric insulation: ________________ minutes

FABRIC REFLECTION CHART

FABRIC COLOR	REFLECTION DIAMETER (FT/IN)

ENERGY EFFICIENCY IN NUTRITION

USE WITH:
General Science
Home Economics

TIME:
2 class periods

MATERIALS:
Reference materials
on menu planning
and use of ovens
Bulletin board

Objectives

The student will:

1. Identify the significance of recipes that require low energy sources for conservation in the home.
2. Research tips for efficient use of ovens for effective energy conservation practice.
3. Prepare and compare recipes for low energy usage in cooking.

Background Information

Cooking requires a great deal of energy. Some cooking methods require more cooking time than others. Some tips for conserving energy while cooking are:

a. Keep oven clean for better reflection of heat and quicker cooking.
b. Do not peek in the oven; each time the door is opened, the temperature drops 25 to 50oF.
c. Never use ovens for heating kitchens.
d. Plan meals that can be cooked in the oven at the same temperature.
e. Preheat oven for only 10 minutes (or less).

Some energy use statistics on cooking appliances are:

Cooking Appliance Energy Use:	Avg. Annual kWh	Avg. Watts
Electric range with oven	1152	12,200
Electric range w/self-cleaning oven	1224	12,200
Microwave oven	300	1,450
Electric frying pan	190	1,196
Deep fryer	83	1,448
Broiler	100	1,436
Roaster	205	1,333
Waffle iron	22	1,116
Coffee maker	110	894
Toaster	40	1,146
Mixer	10	127
Gas appliances	(Contact your local gas co.)	

*Average Watts times Hours Used and divided by 1000 equals kilowatthours.

Procedures

1. Using the background information, discuss with the students how energy can be saved when cooking.

2. Have students compose a dinner menu for four. The menu should include at least 3 recipes and be nutritionally sound and have representative food from a variety of food groups. Have them indicate on each recipe how many watts it would take to cook the meal.

3. Have the students display the menus in the class.

4. Compare menus for energy efficiency in a class discussion.

5. Look for a solar oven design to demonstrate "free energy" for preparing foods. (The Energy Sourcebook contains an activity for using a solar oven.)

Discussion

1. Ask students if they have become more aware of conserving energy through cooking.

2. Have they discovered any techniques which they intend to use again?

Resources

"Kilowatt Counter: A Consumer's Guide to Energy Concepts, Quantities, and Uses." Alternative Sources of Energy. 1974

Tennessee Valley Authority. Appliance Energy Use Fact Sheet. N.p.: TVA, n.d.

GLOSSARY

Alcohol:	Any of various compounds that are analogous to ethyl alcohol in constitution and that are hydroxyl derivatives of hydrocarbons.
Amperage:	The strength of an electric current expressed in amperes (I).
Bauxite:	An impure mixture of earthy hydrous aluminum oxides and hydroxides and the principal source of aluminum.
Btu:	British thermal unit - the amount of energy that is needed to raise the temperature of one pound of water one degree Fahrenheit.
Caulking:	Waterproofing compound or material used to stop up and make watertight seams and cracks.
Clerestory:	An outside wall of a room or building that rises above an adjoining roof and contains windows.
Coal:	A solid, combustible fossil fuel formed by the decomposition of vegetable material without free access to air.
Cogeneration:	A procedure for generating electric power and useful heat in a single installation. The useful heat may be in the form of steam, hot water, or hot air.
Combustion:	The process of burning.
Conservation:	Careful use of a natural resource to keep from wasting it.
Crude oil:	A natural mixture of hydrocarbon liquids.
Cubic feet:	A volume measure of gas equal to one cubic foot on an edge.
Dehumidify:	To remove moisture from the air.
Density:	The mass (or weight on earth) of a unit volume of any substance at a specified temperature.
Efficiency:	Ratio of work to energy expended.

Electric demand charge:	A charge to industrial customers for peak power requirements experienced even for an instant during an established period of time.
Electromagnetic radiation:	Energy propagated as waves resulting from oscillating electric and magnetic fields.
Energy:	The capacity to do work.
EER:	Energy Efficiency Ratio - the rate at which heat is removed from the surroundings, expressed in British thermal units per hour, divided by the rate of energy input (or power) in watts required to operate the machine and associated air blower.
Fluorescent:	Emission of or the property of emitting electromagnetic radiation as visible light resulting from and occurring only during the absorption of radiation from some other source.
Foot-candle:	Intensity of light at a distance of one foot from a standard candle (see standard candle).
Fossil fuel:	Coal, oil, and natural gas derived from the remains of prehistoric plants and animals.
Gallon:	A unit of liquid capacity equal to 231 cubic inches, or four quarts.
Garbage:	A food waste.
Geothermal:	Energy present as heat in the earth's crust.
Heat:	A form of kinetic energy resulting from the random motions of molecules.
Heat exchanger:	A device by which heat is transferred from one material or fluid to another.
Humidity:	A measure of the water vapor content of a gas, typically air.
Humidity:	A measure of the water vapor content of a gas, typically air.
Hydroelectric power:	Electric power generated by flowing water in descending from a higher to a lower level.
Incandescent:	Light given off by a filament when heated to incandescence by electric current.

Insulation:	A material that is a poor conductor of electricity and helps prevent heat loss.
Joule:	The work done when the point of application of a force of one Newton moves a distance of one meter in the direction of the force.
Kilometer:	1,000 meters, or 39,370 inches, or 3,280.8 feet, or 0.621 miles.
Kilowatt:	A unit of electric power equal to 1,000 watts.
Kilowatthour:	A quantity of electricity; a unit of work equal to one kilowatt for one hour.
Kinetic energy:	The energy of motion; the ability of an object to do work because of its motion.
Liter:	A metric unit of capacity equal to the volume of one kilogram of water at 4 degrees Celsius and at standard atmospheric pressure of 760 millimeters of mercury.
Lumens:	Measure of light intensity: one lumen per square foot equals one foot-candle.
Mercury vapor:	An electric lamp in which the discharge takes place through a mercury vapor.
Meter:	The basic metric unit of length equal to approximately 39.37 inches.
Methane gas:	The main component of natural gas.
Methane generation:	An anaerobic digestion process in which microorganisms digest biomass directly to produce methane and carbon dioxide. This process is currently used for industrial and municipal waste treatment to reduce the volume of organic sludges prior to disposal.
Mile:	5,280 feet, or 1.609 kilometers.
Miles per hour (MPH):	The total number of miles traveled in one hour.
Natural Gas:	A fossil fuel that is usually a combustible mixture of methane and heavier hydrocarbons.
Nonrenewable:	Cannot be replaced or regrown.

Nuclear fission:	The splitting of heavy nuclei into two or more parts with the release of large amounts of energy and one or more neutrons.
Oil refinery:	Factory for cleaning petroleum and making it a useful fuel.
Odometer:	An instrument for measuring the distance traveled.
Petroleum:	A naturally occurring flammable liquid consisting of a mixture of complex hydrocarbons.
Photovoltaics:	Certain sensitive materials that generate electricity when sunlight strikes them.
Pollution:	Impureness or dirtiness. The accumulation of wastes or by-products of human activity producing undesirable environmental effects.
Potential energy:	Energy not associated with motion but stored.
Power:	The amount of work done or energy transformed or transferred in unit time.
Recycling:	Reusing materials.
Relative humidity:	The ratio of the actual vapor pressure in a given volume of air to the vapor pressure that could be present if the air were saturated, temperature remaining constant.
Resource:	A natural supply; available to be produced and used when needed.
Short ton:	A unit of weight equal to 2,000 pounds. A "long ton" is equal to 2,240 pounds.
Specific heat:	The ratio of the quantity of heat required to raise the temperature of a body one degree to that required to raise the temperature of an equal mass of water one degree.
Solar radiation:	The total electromagnetic radiation emitted by the sun.

Sodium vapor:	An electric lamp that contains sodium vapor and electrodes between which a luminous discharge takes place.
Standard candle:	A unit of luminous intensity equal to one sixtieth of the luminous intensity of one square centimeter of a black body surface at the solidification temperature of platinum.
Temperature scales:	Scales by which degrees of hotness and coldness are measured.
Trash:	Something worth little or nothing; rubbish.
Vapor pressure:	The pressure exerted by a vapor that is in equilibrium with its solid or liquid form.
Waste heat:	Heat that is allowed to escape without being utilized.
Watt:	Unit of electricity equal to one Joule per second; the rate of work represented by a current of one ampere under pressure of one Volt.
Weatherstripping:	Covering the joint of a door or window and the sill, casing, or threshold so as to exclude rain, snow, and cold air.

REFERENCES

AIA Research Corporation. Regional Guidelines for Building Passive Energy Conserving Homes. Washington, D. C.: AIARC, n.d.

Air-Conditioning and Refrigeration Institute. Directory of Certified Unitary Air-Conditioners, Unitary Air-Source Heat Pumps, Sound-Rated Outdoor Unitary Equipment. N.p.: ARI, 1986.

Air-Conditioning Contractors of America. Load Calculation for Residential Winter and Summer Air-Conditioning. 4th ed. N.p.: ACCA, 1975.

Alabama Energy Extension Service, Alabama Department of Economic and Community Affairs. The Car Fitness Book. N.p.: ADECA, 1984. (Write: ADECA, 3465 Norman Bridge Road, Box 2939, Montgomery, Alabama 36105-0939. Call: Ms. Adams-Folmer at 205-284-8936 or, in Alabama, at 1-800-329-8098.)

________. Energy Conservation computer program). N.p.: ADECA, 1985. (Write to address above or call Ms. Robinson at 205-284-8937 or in Alabama, call toll-free number above.)

________. Home Energy Conservation (computer program, grades 6-12). (Contacts as above.)

Alabama Environmental Quality Association. Recycling: Unburied Treasure. Montgomery, Alabama: EnviroSouth Inc., 1981. (Write: EnviroSouth Inc., Box 11468, Montgomery, Alabama 36111.)

________. The Recyclopedia. Montgomery, Alabama: EnviroSouth Inc., 1982. (Contact as above.)

American Institute of Architects. Energy Conservation in Building Design. N.p.: AIA, 1974.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. ASHRAE Handbook, 1985 Fundamentals. New York: ASHRAE, 1985.

Anderson, B. The Solar Home Book. Harrisville, NH: Chesire Books, 1976.

Dorf, R. C. The Energy Factbook. New York: McGraw-Hill, 1981.

Fowler, J. M. Energy and the Environment. 2nd ed. New York: McGraw-Hill, 1984.

Halacy, B. and D. Halacy. The Solar Cookery Book. N.p.: Peace Press, 1978.

Honeywell Corporation. Energy Conservation with Comfort. N.p.: Honeywell, 1979.

"Kilowatt Counter: A Consumer's Guide to Energy Concepts, Quantities, and Use." Alternative Sources of Energy (1974).

McPherson, B. Hot Water from the Sun. N.p.: The Franklin Research Center, n.d.

Mass, S., ed. Factbook Of Electrical Food Service Equipment. 34th ed. N.p.: N.p., 1977.

Mazria, E. The Passive Solar Energy Book. Emmaus, PA: Rodale Press, 1979.

Millison, J. and S. Adams, eds. National Construction Estimator. N.p.: Craftsman Book Company, 1986.

National Association of Realtors. The Realtor's Guide to Residential Energy Efficiency. N.p.: NAR, 1980.

National Bureau of Standards. Energy Conservation Program Guide for Industry and Commerce. (Handbook 115.) Washington, D.C.: NBS, 1974.

________. Waste Heat Management Guidebook. (Handbook 121.) Washington, D.C.: NBS, 1976.

National Electrical Contractors Association. Total Energy Management: A Practical Handbook on Energy Conservation and Management. N.p.: NECA, 1976.

National Geographic Society. Energy: Tracing Up to the Problem, Getting Down to Solutions. Washington, D.C.: NGS, February 1981.

Olin, H. B. and R. J. Laya. Energy Conservation and You. N.p.: United States League of Savings Associations, 1978.

Shurcliff, W. A. Thermal Shutters and Shades. Andover, MA: Brick House Publishers, 1980.

Stein, R. G. Architecture and Energy. New York: Anchor Press, 1977.

Tennessee Valley Authority. Appliance Energy Use Fact Sheet. N.p.: TVA, n.d.

________. Electrical Energy Conservation Guidelines - for Commercial and Institutional Buildings. N.p.: TVA, [1984?].

________. Electrical Energy Conservation Guidelines - for Industrial Facilities. N.p.: TVA, [1981?].

________. Energy Saver Home Standards. N.p.: TVA, [1981].

________. Safe and Warm Wood Heat. N.p.: TVA, [1981?]

________. Solar Homes for the Valley. N.p.: TVA, [1981].

United States League of Savings Associations. A Clipbook of Energy Saving Ideas in Home Building. N.p.: USLSA, 1980.

U.S. Department of Commerce. *Making the Most of Your Energy Dollars in Home Heating and Cooling*. N.p.: USDOC, 1975.

U.S. Department of Energy. *Architects and Engineers Guide to Energy Conservation in Existing Buildings*. N.p.: USDOE, 1980.

________. *Energy Audit Workbook for Office Buildings*. N.p.: USDOE, 1978.

________. *Energy Conservation: Homes and Buildings*. N.p.: USDOE, 1979.

________. *Energy Conservation: Transportation*. N.p.: USDOE, 1979.

HYDROPOWER

OVERVIEW

Leonardo da Vinci saw water as the busiest substance. He called it "the element that knows no rest." Like wind, water has been used to provide humans with energy for thousands of years. It has served as the world's oldest highways and provides a form of cooling for animals and people suffering the effects of warm weather. Its abundance is outdone only by its magnificent, raw mechanical strength, as illustrated by such disasters as floods and tidal waves.

Hydropower may be the oldest energy-generating technology. The strength of water has impressed man from the beginning and was probably tapped long before recorded history. Simple waterwheels were first used in ancient times for mechanical processes like grinding grain. Later, water wheels supplied energy for the more complex machinery of the early Industrial Age. Throughout his history, man has used the energy of moving water to power water supply systems for his homes, crops and livestock.

Hydropower technology has matured, and new uses of water's energy have been found. From historic water wheels, turbines for generating electricity were developed. Hydroelectricity is a relatively recent technology. Development, refinement, first applications, and widespread use all occurred in the 19th century. Most of the refining of water turbines was done in the first half of the 1800s. In 1882, the first central hydroelectric generating plant was built in Appleton, Wisconsin to power 250 electric lights. The country became dotted with small hydropower sites. Though literally thousands of these have been closed down in the 1900s, the United States still relies on hydropower to some degree, generating 66,817 megawatts of electricity in its existing plants. (In 1977, this amounted to 12 percent of the nation's requirements for electricity. In the mid-1930s, hydroelectric power provided about 30 percent of total requirements.)

Hydropower's availability and use varies in different areas of the nation. In the Tennessee Valley, it has been an especially significant resource. In 1984, hydropower provided almost 20 billion kilowatthours of electricity, or 18 percent of the total power output of the TVA transmission system. However, rainfall levels affect the availability of hydroelectricity. In 1985, a very dry year, hydroelectricity fell to less than 14 billion kilowatthours, or 12.5 percent of the total output. Even so, the Valley still relies on TVA's hydropower system of 30 dams it has built or acquired since 1933 to produce inexpensive electricity.

Nine of these projects are on the Tennessee River, 20 are on tributary streams, and one is in the Cumberland River basin. These 30 dams are the Valley's cheapest energy source, the cost in cents per net kilowatthour of hydropower being only 0.25 cent as compared to 2.17 cents for coal-fired power and 2.45 cents for nuclear power.

The amount of energy recovery from rivers, streams, and lakes is an enormous, almost incalculable quantity. It may be that only a tiny portion of the available water power is suitable for harnessing, but its potential in the United States has been estimated as tens of thousands of additional megawatts.

TO BUILD OR NOT TO BUILD

Objectives:

The student will:

1. List advantages of hydroelectric power.
2. List disadvantages of hydroelectric power.
3. Play roles of citizens and/or government groups to decide the issue of building a dam.
4. Make a decision concerning the construction of a dam, in a simulated town-board meeting.

USE WITH:
History
Geography
Sociology
Government
English
General Science

TIME:
2 class periods (additional time for research)

MATERIALS:
Worksheets (included)

Background Information

Hydroelectric power has many advantages as a power source. There are disadvantages of producing electricity from hydropower also, as there are for all power sources. In this activity, students role-play as leaders and citizens in making a collective decision on whether or not to build a hydroelectric dam near the imaginary town of Flat Rock.

The main advantages of hydropower are its efficiency, economy, renewability, and cleanness. A hydroelectric plant requires no fuel, converts the energy of moving water at 80 to 90 percent efficiency, produces no pollutants, and relies on the water cycle rather than a finite resource. Other power sources are much more costly, convert the energy of nonrewable fossil or nuclear fuels at efficiencies of 30 percent or less, and produce by-products having various detrimental environmental effects.

Often a hydroelectric dam is a multipurpose dam. It can help to control seasonal flooding, thereby protecting the communities downriver from flood damage. The lake formed above a dam can be developed as an important recreation area for camping, boating, and fishing. The power supplied by a hydro plant can improve the economic well-being of the area and attract industry.

Just as many things are gained when a river is dammed for hydropower, many are also lost. When a reservoir is flooded, land, often much of it prime farmland, is lost. The land is irretrievably gone, but the lake is not itself permanent. Eventually, sediments from upriver will "silt up" the reservoir, rendering the dam and the former lake useless. Some of these sediments would be deposited on floodplains downstream, enriching and renewing the land if not for the dam.

Damming a river changes land and aquatic habitats above and below the dam. Plant and animal species are lost with the flooding of the reservoir. Fishing in the lake actually improves for about 10 years but then declines unless periodic restocking is undertaken. Below the dam, the quality of the habitat declines because the dam raises the temperature of the water, causing the oxygen content to decrease. This causes a decrease in the numbers of trout and similar gamefish in the river. (Norris Dam, TVA's oldest, discharges cold water from the bottom of the lake into the Clinch River, but it too is oxygen-deficient because it is from the reservoir's depths. TVA has installed special oxygenating equipment at the dam to raise the levels of dissolved oxygen in the discharged water in efforts to improve downstream habitats.)

When a decision to build or not to build a dam is made, all these advantages and disadvantages are weighed carefully. Everything has its price; society decides which it will pay.

Procedure

1. Students are assigned roles from the following list. The citizen groups can be as large or small as you wish to allow the entire class to be involved.

   Limestone County Board of Supervisors (7 members)
   Ledbetter Engineering Associates
   Flat Rock Electric Company
   Valley Textiles, Inc.
   Flat Rock Area Business People
   Limestone Game and Fish Association
   Friends of Flat Rock Forests
   Flat Rock Farmers
   Homeowners' Association
   County Planner
   Citizens of Flat Rock

2. Give each individual or group its role and a problem sheet. These sheets will give your students the background they need. The Board of Supervisors should be given all of the role cards.

3. Discuss the problem sheets with them. Before beginning, answer any questions they may have about their roles. It is also important to discuss the ways they perceive their roles. What are their responsibilities as citizens or board members?

4. Allow the students a day or two to prepare their statements and to conduct any research necessary before presenting their statements.

5. Each group should choose a spokesperson to present its point of view to the board.

6. The board chairman will start the meeting by explaining the issue and restating the alternatives listed on the problem sheet. Allow each group three minutes to present its statement to the board. The board can also decide to offer a different alternative from those presented in the problem. If it does, its alternative should be heard before the question and answer session; then the meeting should be recessed to allow the groups time to consider the board's proposal.

7. After each statement, the board should be allowed to ask questions of the group. At this point, any group member can answer the board's questions.

8. Allow about 10 minutes for discussion and rebuttal after all statements have been heard.

9. Have the board recess for 5 minutes to make its decision. Members may choose not to build the dam or choose another alternative if one of the dam building alternatives is not chosen. When the decision is announced, they must give reasons for their choice and explain that decision.

10. Follow with discussion.

Discussion

These questions may be used to discuss the alternatives, issues, and decision-making processes used in this investigation:

1. What difficulties were encountered in preparing defenses for each of the positions? What role did bias play in this preparation?

2. What additional information would have been helpful in reaching a decision?

   (The cost of the dam and power plant is the only truly factual information given in this activity. Have students name some other numerical information of interest. Examples: the acreage of the reservoir and the effect on taxes or utility bills.)

3. What factors did the Board of Supervisors consider when making its decision? What other factors do class members think the board should have considered? What factors do students think should be considered in determining the welfare of the county as a whole?

4. Identify the people whose needs were considered by the Board as it formulated its plan.

   a. What effect did the special interest groups and their statements have on the board? What part should special interests play in the board's decision-making process?

   b. Are there county residents whose needs were not represented? Were their interests identified and considered in any way? How might they have been considered if they were not?

5. Did anyone's point of view change as a result of the hearing?

6. Were any compromises made to enable the board to make its decision? If so, what compromises?

Instructions

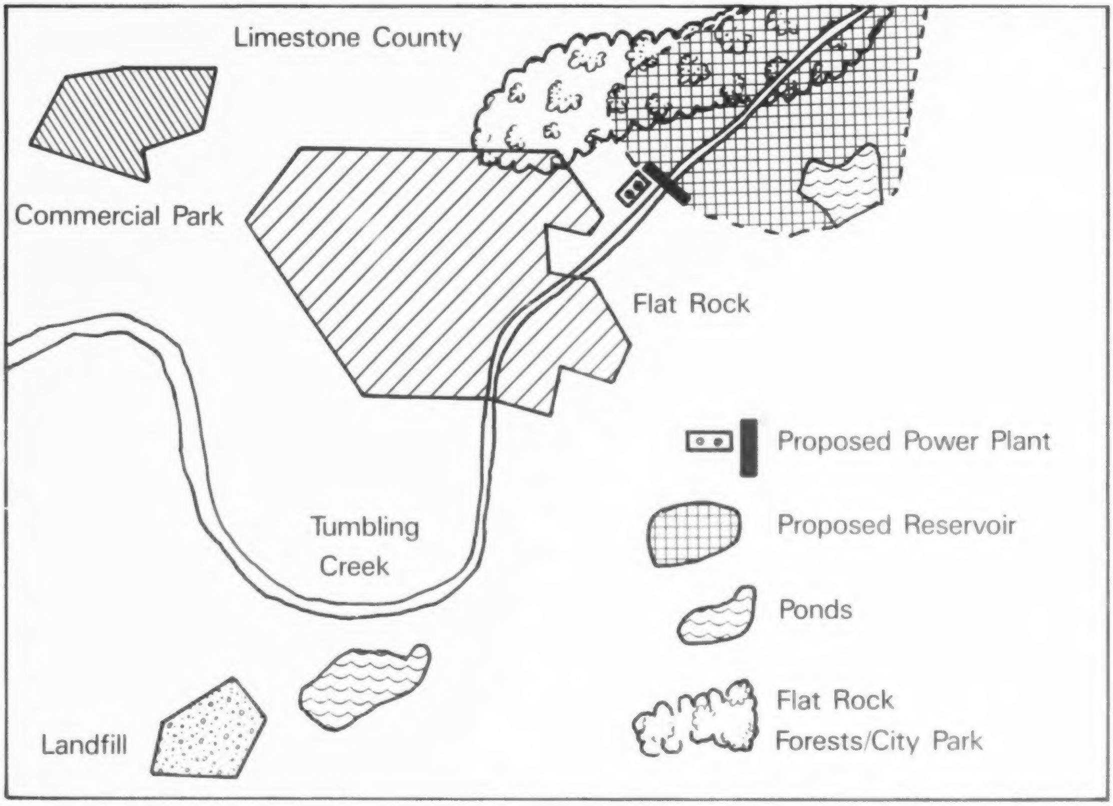
You are to make a decision concerning placement of a hydroelectric facility on a local stream. Each of you will be assigned roles from the following list:

- Limestone County Board of Supervisors (7 members)
- Ledbetter Engineering Associates
- Flat Rock Electric Company
- Valley Textiles, Inc.
- Flat Rock Area Business People
- Limestone Game and Fish Association
- Friends of Flat Rock Forests
- Flat Rock Farmers
- Homeowners' Association
- County Planner
- Citizens of Flat Rock

1. You will be given a role description sheet.
2. You are to conduct any research necessary before preparing your statement to be given before the board.
3. You are to elect a spokesperson who will present your statement to the board.
4. Your presentation must not exceed three minutes. The board may also ask you questions concerning your ideas.

Problem Sheet

The Mayor of Flat Rock was approached by Valley Textiles, Inc., and informed of the company's desire to expand its operations in Limestone County. However, in order to expand, the plant will require more electricity than before. The Flat Rock Electric Company, which provides all the electricity for Flat Rock and Limestone County, is currently unable to provide the amount needed. If Valley Textiles, Inc., cannot get this electricity, they may have to relocate in another area. After considering several alternatives, including importing power from other companies, Flat Rock Electric has consulted with Ledbetter Engineering Associates and is recommending damming Tumbling Creek and building a hydropower plant. It will cost $1.2 million to build the dam and power plant, but it is expected this will draw new industries to the area and provide additional flood control. All concerned parties have gathered at the County Board of Supervisors' meeting to discuss the issue.


Limestone County
Commercial Park
Flat Rock
Tumbling Creek
Landfill
Proposed Power Plant
Proposed Reservoir
Ponds
Flat Rock Forests/City Park

Role Descriptions

1. Limestone County Board of Supervisors (7 members)

   The decision rests with you. Should Tumbling Creek be dammed and a hydropower plant built? It is up to you to recognize your own special interests and the interests of each group making statements before the board. The decision you make must go beyond the special interests of any one group and consider the best interests of the county as a whole.

   Your first task is to select three board members who live in and represents the area where the dam will be located. Then you should consider these questions:

   a. What are the advantages and disadvantages of building a dam and a hydropower plant? What, if any, other options can you consider?

   b. How do you take into consideration the feelings of the local citizens in making your decision?

   c. What criteria are you going to use to analyze the statements made by the citizens? Make a list of them.

   d. What factors beside local citizen reaction will you be considering as you work toward a decision?

   e. What parts will all of the factors play as you reach a decision?

   f. Is there room for compromise in reaching a decision? If so, do you think citizens will be willing to make compromises? In what ways? What compromises can you offer them?

   You can ask questions of each group after it has presented its point of view. As a group, consider all the alternatives. If you like, you can consider other solutions as well and present them to the citizens at the beginning of your board meeting. If you decide to do this, recess the board meeting and allow each group to consider your proposal and develop lists of questions and concerns to be answered before you make the final decision.

2. Ledbetter Engineering Associates

   You have been working with the Flat Rock Electric Company to develop the hydropower plant proposal. Your role is to discuss not only the additional power provided but also the impact on the environment. You will present to the board an Environmental Impact Statement. Do not forget to discuss flood control which is needed for farmers whose prime farmland is located on the banks of Tumbling Creek.

3. Flat Rock Electric Company

   You are excited about the prospect of expanding the facility and your services to the community. Because you are a public utility, the funding for this facility will be from municipal bonds. Your role is to discuss the economic benefits to the community, i.e., new industries coming to the area, and increased tourism for recreation such as boating and campgrounds.

4. Valley Textiles, Inc.

   This business is a special interest group. They need additional power to increase their production of textiles. The president of the company would like to stay in Limestone County. His employees are happy; the schools are good, and they like living in Flat Rock. He does not want to lose valuable employees if he has to relocate. Also, to relocate would cost more capital than he has available, but he will relocate his company if necessary, as he will recoup his expenses within 10 years. Although he has an interest in the new dam, he also has an interest in the community. He pledges to work closely with the community and the State Environmental Department to have as little effect on the stream environment as possible.

5. Flat Rock Area Business People

   You are interested in expanding the community. However, there is some concern about the costs and possible increases in city and county income tax, property taxes, and electric bills.

6. Limestone Game and Fish Association

   You are opposed to damming the stream because of the effects on fishing. You enjoy fishing in streams, not lakes. You are very proud of Tumbling Creek and enjoy fishing in the same spots your grandfathers fished in. This dam means losing an important piece of your heritage.

7. Friends of Flat Rock Forests

   You are opposed to building a dam. This would mean flooding forests and areas in which you enjoy bird watching, nature walks, fishing, hunting, and family picnics. While you recognize some of these activities would still be possible with a reservoir, you are very proud of your stream and do not want to give it up to development.

8. Flat Rock Farmers

   You are interested in flood control for your land which borders Tumbling Creek. However, you are concerned at the acres of farmland which will be flooded to create the reservoir.

9. Homeowners' Association

   You are excited about the prospects of developing new lakefront communities and the recreational opportunities it would bring to the area. You see community growth as good and feel this project would mean a lot of money in home sales and possibly increase the values of property in the area. More property taxes coming in mean better schools, roads, firefighting, and police services.

10. County Planner

    You have mixed feelings about the proposal and wonder if hydropower is the best alternative in the long run for the community. You agree that the county needs to increase the power available in order to grow; however, you would like to see other power-producing alternatives considered.

11. Citizens of Flat Rock

    Each of you has his/her own opinion but is anxious to listen and consider all the information presented. You want what is best fo everyone in the community.

A HOME-MADE WATER TURBINE

Objectives

The student will:
1. Explain how water turbines work.
2. Determine the relationship between the distance the water falls and the speed at which the water turbine turns.

USE WITH:
General Science
Physical Science
Physics

TIME:
1 class period

MATERIALS:
(groups of 2-4 students)
For each group of students:
1 2-L plastic bottle
1 set tinker toys
1 roll electrical tape
1 package small cups (approximately 6 cm diameter)
1/2" plywood (scraps will do)
Epoxy or other glue
Nails
Worksheet (included)

Background Information

Hydropower systems range from crude water wheels to hydroelectric dam systems like that on the Tennessee River. Water wheels, which were historically very important (e.g., gristmills and textile mills), convert the kinetic energy of moving water to mechanical energy. Hydroelectric systems convert the kinetic energy of moving water to electrical energy with a turbine, a streamlined water wheel powering a generator which produces electricity.

Overshot wheels, undershot wheels, and breast wheels are named for the position at which the water strikes them, turning them in a vertical plan. The only water wheel currently in production turns in a horizontal plane and is fed by a relatively sophisticated wooden channel or penstock; it is produced in Europe. Water wheels may be modified for electrical generation, but durable, efficient and reliable water systems for electrical generation utilize high-speed turbines.

The water turbine differs from the water wheel in that pressurized water is jetted into the blades and leaves with little velocity left, 80 to 90 percent of the available kinetic energy having been transmitted to the rotor. Turbines are much better suited for coupling with electric generators because they spin at a suitably higher speed. There are various types of turbines and each has a slightly different efficiency, but all of them are more efficient in generation than are water wheels, although they are more expensive.

Procedure

1. Divide class into groups of 2 to 4 students. For each group of students prepare the following components.

   Cut the following out of 1/2" plywood or similar wood scraps:
   Base - 5" x 7"
   2 Supports - 2" x 5"
   Spacer - 2" x 2"

   Drill 1/4" holes in supports 1" from top. Make sure tinker toy shaft turns freely in holes. Drill 1/4" hole in bottom of 2-L plastic bottle.

2. Discuss with class conversion of energy from flowing water's kinetic energy to energy usable by man.

3. Demonstrate construction and use of water turbine model.

4. Distribute student materials.

5. Supervise activity (repetitions are recommended for accuracy).

6. Follow with discussion.

7. This project, or modifications of it, can be done at home for extra credit or enrichment. Encourage students to experiment with various turbine designs.

Discussion

1. Graph the relationship between the distance the water falls and the number of revolutions per minute. Place distance (cm) on the horizontal axis and number of revolutions per minute on the vertical axis. What relationship does this graph represent?

   Graph should show straight line. Represents direct relationship between height of water falling and number of revolutions per minute.

2. Express this relationship in terms of potential and kinetic energy.

   Potential energy of water in bottle converted to kinetic energy of falling water, some of which is converted to kinetic energy of turning turbine.

3. If electricity were generated with this water turbine, which trial would generate the most? Why?

   Last trial (height of 40 cm). Height greater - energy greater.

HOMEMADE WATER TURBINE

Instructions

1. Build the turbine. (Refer to diagram.)

   A. Obtain the following wooden pieces:
      Base - 5" x 7"
      2 Supports - 2" x 5"
      Spacer - 2" x 2"

   B. Assemble base supports using nails and/or glue.

   C. Assemble tinker toys as shown:
      1. Shaft (5")
      2. Round tinker toy for center of wheel
      3. (8) 3" spokes to hold cups

   D. Cut 8 small paper cups for buckets (as shown)

   E. Glue cups on tinker toy spokes using epoxy or similar fast drying glue.

   F. Assemble as shown and wrap tape collars on shaft to keep turbine in place.

2. Fill the 2-L bottle (with 1/4" hole in bottom) with water. Cap and turn upsidedown until ready to use.

3. Place the water turbine on the edge of a sink with the turbine assembly extending over the edge.

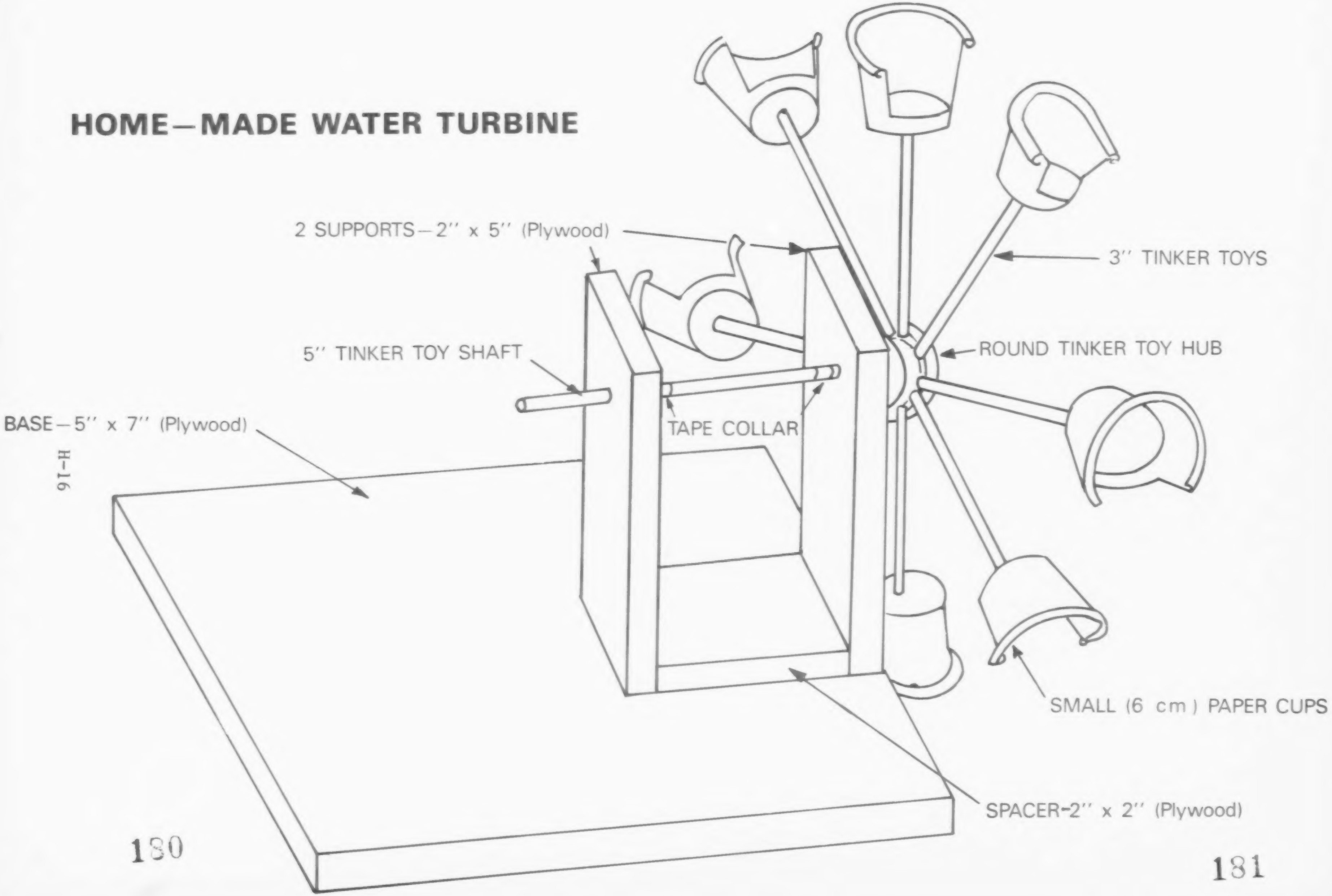
4. Hold a meter stick next to the turbine.

5. Turn the bottle of water upright at a distance of 10 cm above the turbine, making sure the stream of water from the bottle strikes the cups. (Loosen cap to aid water flow.)

6. Count the number of revolutions during a 30-second period at a distance of 10 cm (a revolution can be more easily seen if a mark is placed on the center of the turbine; see illustration below). Double this count and record in Data Table as revolutions per minute.

7. Refill the bottle and repeat at distances of 20 cm, 30 cm, and 40 cm. Record in Data Table.

HOME—MADE WATER TURBINE


2 SUPPORTS—2" x 5" (Plywood)
3" TINKER TOYS
ROUND TINKER TOY HUB
5" TINKER TOY SHAFT
BASE—5" x 7" (Plywood)
TAPE COLLAR
SMALL (6 cm) PAPER CUPS
SPACER—2" x 2" (Plywood)

DATA TABLE

TRIAL	DISTANCE WATER FALLS (CM)	NUMBER OF REVOLUTIONS PER MINUTE
1	10	
2	20	
3	30	
4	40	

GRISTMILLS: WATER WHEELS OF YESTERDAY

USE WITH:
Industrial Arts
Geography
History
Sociology

TIME:
3-5 class periods

MATERIALS:
Reference books
Community resources

Objectives

The student will:

1. Explain how gristmills harness water power.
2. Explain the historical role of gristmills in the Industrial Revolution.

Background Information

Water power played a major role in the Industrial Revolution in Europe as well as in the industrialization of early America. Gristmills were among the most common usages of waterpower. In New England, entire factories were powered by water. In our own area of east Tennessee, sawmills as well as gristmills were run by water power.

Many ruins of water-powered mills are scattered across the country. Sometimes all that remains is some parts of the building or a ripple in the stream where there was a dam. Most of the time the mill or at least the water wheel has been washed away.

Some of the mills used large water wheels with flumes. Some were built right over the water and used large paddles to turn the drive shaft. Each mill was customized by the builder to suit the location, available materials, and the mill's intended uses.

There may be an old mill near your school which could serve as a link to the past.

Procedure

1. Each student will choose a topic relating to gristmills to research and report to the class by using models, sketches or pictures, and an oral account.

2. Contact an expert from a local historical society to lecture about mills in your area.

3. Try to locate an old mill in your area and arrange a field trip to see all of the working parts as well as the channels which carry water to the mill.

4. After class presentations and the field trip, discuss the following questions with the students.

Discussion

1. How is gristmill technology used today? How is grain milled today?

   Technology which developed from gristmill technology is used to grind feeds for animals as well as for people, grind medicines, crush rocks, make lime and cement, grind tools, and make many other products. However, the machinery in use today is powered by electricity. The turbines in hydroelectric generators are technological descendants of water wheels like those used in gristmills.

2. How is a gristmill like a hydropower plant? How is it different?

   They are alike in that both use water power as the source of energy.

   They are different in that in gristmills the power of the falling water is used directly (to turn the stone which grinds the grain) whereas hydropower plant produce electricity which is then used for a variety of tasks. The technology of hydroelectricity developed from simple water wheels, but is much more sophisticated.

3. Do you think it is important to preserve old gristmills? Why?

   Gristmills are links to the past and should be preserved for their historical value. In addition, they could have implications for the future as economical alternative energy technologies are sought. Some experts believe that part of the solution to the energy crisis will be found in returning to some of the smaller-scale, simpler devices of the past which do not rely on non-renewable energy resources.

4. Why do we attempt to preserve our heritage? Why is it important to do this?

   There are numerous reasons. Only the past is certain, and it is needed as a guide to the present and the future. Values and measuring right and wrong are learned from the past. An appreciation of the labor-intensive lifestyles of earlier generations of Americans and an understanding of energy's growing role in daily life helps form a sound basis for the value-laden decisions students will be called upon to make as adults.

AQUATIC HABITATS IN RESERVOIR AND STREAM ECOSYSTEMS

Objectives

The student will:

1. Distinguish between aquatic habitats in a reservoir and below the dam by investigating them and constructing a map and charts of the area.
2. Identify the chemical and biological characteristics of an aquatic reservoir by conducting chemical tests of the water and analyzing the biotic factors that influence the reservoir.
3. Compare the three different habitats investigated on the field trip by developing charts and food webs, assessing likenesses and differences, and reporting findings to the class.

USE WITH:
Biology
General Science
Environmental Science

TIME:
(Field Study)
2-5 class periods*

MATERIALS:
3 Meter or yardsticks
1 Weighted rope or string
3 Microscopes with slides/cover slips
3 Thermometers (C & F)
1 pH water test kit**
1 CO_2 water** test kit
1 Dissolved oxygen kit
1 Plankton net (homemade or bought)
Assorted jars and collecting trays
Field Identification books
Worksheets (included)

Background Information

A dynamic biotic community is dependent upon the integration of the physical, chemical, and biological environmental factors. Students can see this relationship best by visiting a nearby reservoir. The transition periods from summer to fall and from winter to spring are perfect times to take your class on a field trip. A reservoir of some kind can usually be found within a reasonable distance from your school.

---

*Time variable. (Can be designated according to class and objectives.)

**These kits can be purchased at a reasonable price from most biological supply houses. Hach and Lamotte companies make good ones.

Many factors affect the life in streams and reservoirs. Some of them are:

A. Velocity: The velocity of a stream determines the type of food present and feeding strategies of the organisms present as well as influencing dissolved oxygen content. Velocity also influences the type of aquatic animal life present in the stream. For instance, darters prefer swift water, sunfish prefer calmer pools and catfish and paddlefish live in slow, calm reservoirs.

B. Dissolved Oxygen: The cool temperature of mountain streams, when combined with the large number of waterfalls and riffles, results in water with high oxygen content. When water temperatures rise, dissolved oxygen goes out of solution and into the atmosphere. Dissolved oxygen in lakes depends on the season of the year. Typically, lakes are higher in dissolved oxygen in the spring and lower during fall months. Sometimes the streams below dams are very low in dissolved oxygen because the power generators use the bottom waters of the reservoir which are naturally low in dissolved oxygen. This problem is in the process of being resolved. For example, at the Norris Hydroelectric Dam the generators are vented to allow oxygen to be released along with the water.

C. pH: The pH level also affects the distribution of aquatic life. When the pH of a stream is in a range of 6 to 9, the body of water has the potential to support abundant life. If the pH is 10 or more, the stream will be conducive to minimum levels of life. Likewise, if the pH is 5 or below, the water will be too acidic for most life forms.

D. Type of Bottom: The bottom plays a very important role in determining what types of organisms will be present. Sandy bottoms are the least productive, as they offer little substrate for either protection or attachment. In streams, it is important for many bottom-dwelling organisms to have a place of attachment to prevent them from being swept away by the current. Bedrock in streams is also essentially nonproductive because aquatic organisms are totally exposed to the current on a solid substrate. Gravel and rubble bottoms are most productive. These bottom types offer large areas for attachment sites and provide abundant nooks and crannies in which crustaceans, insects, and larvae can hide.

E. Other Factors--Carbon Dioxide: Carbon dioxide is an odorless, colorless gas produced when animals and bacteria respire. Green plants also respire but release more oxygen during photosynthesis than they use during respiration when light is present. At night plants respire, releasing CO_2 and using oxygen. This tends to increase CO_2 levels and decrease O_2 levels which can cause problems for fish. Levels of CO2 as low as 1.0 to 6.0 mg/l will cause fish to avoid those waters. Carbon dioxide will also affect the pH of the stream as it quickly combines with water to form carbonic acid.

Temperature: The temperature of the water is affected by many variables such as color, depth, shade, latitude, and time of year. Temperature is important to aquatic life since most organisms in water are ectothermic and have minimum and maximum temperature tolerances. Under otherwise identical conditions, colder water has more dissolved oxygen content than warmer water. Warm water also make some substances, such as cyanides, phenol, xylene, and zinc more poisonous to aquatic animals. Most fishes' spawning cycles are disrupted when temperatures rise above normal.

Turbidity: Turbidity is a measure of how "cloudy" water is. The turbidity of the water will affect the ability of light to pass through it and will affect the rise of photosynthesis of plants. High turbidity will also coat the pores and gills of aquatic life and affect respiration. The turbidity may be caused by large amounts of silt, microorganisms, plant fiber, sawdust, chemicals and coal dust. The most frequent causes of turbidity in lakes and rivers are soil erosion from logging, mining, and dredging operations and plankton. All these factors will also contribute to the rate of sedimentation.

Procedure

1. Suggestions for use of this activity:

a. This activity is designed so that all or parts of it may be done. If desired, do only the chemical analysis of the water or the biological investigations. Part F, for example could be optional depending on time available and objectives.

b. Not only may the amount of time spent vary considerably but the level of coverage can be easily adjusted for different courses.

c. Permission slips should be signed by parents and the principal prior to the trip. Arrangements must also be made for transportation if the body of water is not within walking distance of the school. It would be good to have parent volunteers to assist in the field if the class if very large.

d. Choose study sites above and below the dam carefully.

e. Divide the class into three teams.

2. Field Trip Preparation

a. A discussion of the terms relating to the physical and chemical aspects of the habitat must precede the trip. Basic terms such as species, habitat, niche, predator/prey, parasite/host, symbiotic relationships, and adaptations for food-getting by animals should be reviewed before assigning the project. The background information (concepts relating particularly to the aquatic habitat) must be introduced prior to the field trip.

b. Distinguish between a food chain and a food web; give examples and emphasize that a food web is more accurate. A food chain shows simple linear relationships that are helpful, but a food web actually depicts the complex relationships found in nature. Have students practice diagramming a food web.

c. Prepare needed equipment ahead of time. If three groups are to work, then try to obtain three sets of materials. In the case of water test kits, which may be too expensive to have for each group, a rotation cycle may be worked out between the groups.

d. Students should be instructed on how to use and care for the equipment before going to the field. A practice session for each chemical test should be conducted in the classroom.

e. Distribute materials and go over each field exercise in order to familiarize students with each step of the instructions. Each group may then decide on a division of labor and who does what before going to the field.

3. Field Trip

a. Take the class on a reconnaissance of the three habitats to be studied before assigning each group its study area. This will give the entire class a better overall view of the project.

b. Set up a "common field station" where it will be easier for the teacher to monitor and help. The teacher or another adult should supervise each group collecting data at the various habitat stations; this is especially important if the groups are large or spread out.

c. Give the students clear instructions on obtaining their data in the field, preparing their project report, and filling in the data sheets. Also remind them of safety rules and procedures.

d. Students should use the field guides to look up plants, animals, etc. Have them record the common name and genus of each plant and animal on the data sheets. This could be done in class after the field trip if time is limited in the field.

e. Have each group conduct its work at its assigned study site, fill out the data sheets, and be prepared to post the data sheets in class the next day, orally presenting its findings to the class. The entire class can then pool the information to formulate a comparative view of the reservoir and its various habitats.

Discussion

1. After the students have completed their findings about the biological, chemical, and physical differences of the reservoir, a class discussion could be held on the human aspects of the reservoir ecosystem, e.g., alteration of a natural environment to meet human needs.

2. The class could be divided into debate teams for the lake versus the natural stream. Each team could research the pros and cons of both environments and their value to the human population.

Resources:

A Guide to the Study of Freshwater Ecology. Englewood Cliffs, NJ: Prentice-Hall Inc, 1972.

Andrews, W. A. A Guide to the Study of Environmental Pollution. Englewood Cliffs, NJ: Prentice-Hall Inc, 1972.

Jacobson, C. Water Quality Factors. Loveland Company: Hach Company, 1983.

Otto, J. Modern Biology. New York: Holt, Rinehart and Winston, 1985.

Renn, C. E. Investigating Water Problems. Chestertown, MD.: LaMotte Chemical Products Company, 1970.

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT

ACTIVITY SHEET

During the field trip to a reservoir, examine the various features of the habitat, take notes on these activity sheets, and then organize the data and record it on the provided data sheets. Each group is to fill out the data for its assigned area and post there data on the bulletin board for the other two groups. Comparisons can then be made with each group having all the data.

COMPLETE Part A and record data on Data Sheet A

A. 1. Determine the width of the stream in your habitat. Use metric measurements first then standard. For example, stream width = 3 meters/9 feet 6 inches.

2. Determine the average depth of each habitat stream. Take three measurements and divide by four to account for the uneven bottom.

3. List type of vegetation surrounding your area (trees, shrubs, weeds, etc.). Indicate how much area is sheltered or receives direct sun. Estimate by percentage.

4. Make a list of the kind of animal life you can observe in your area. Look carefully for such animal signs as tracks, trails, and droppings, as well as any movement of small animals in the water.

5. Count the varieties of both plant and animal populations. (Later, determine which ones are specific to one habitat and which occur in all three.) In the space provided here, list the different animal and plant populations, indicate their relative abundance, and sort as to location(s) within the area.

Bank	Rocks	Water

B. 1. On data sheet B, keep a record of the plant and animal relationships observed. Use the field guides to determine the scientific names of the dominant plants and animals; record these also. Look for evidence of how the plants help the animals and vice versa. What would be the names for this type of relationship? Look for examples of predation, parasitism, commensalism, and mutualism among animal populations. Would there be any changes in either plant or animal life from week to week? Using educated guesses based on observations, try to determine the growth and development of living things as either positive or negative.

2. Compare these observations with those of classmates.

C. 1. Look for relationships between the living (biotic) and nonliving (abiotic) features of the community. Record these on data sheet C-1 and C-2.

2. First establish a food chain that would be found in the community. Then, using information already gathered, draw a food web on data sheet C-2. Leave space enough to add organisms when the three webs are compared.

3. Look for evidence of pollution of the habitat. What type of pollution is observable? Record this on data sheet C-1. Is this pollution caused by man or is it natural? Your chemical tests may aid in these observations.

4. What abiotic factors would influence the plant and animal adaptations to the habitat? Predict what the pH, dissolved oxygen, and CO2 levels might be before conducting the chemical tests. Would other factors such as depth, space, or light affect these relationships? What about temperature?

5. List the effect of sunlight on the habitat. Why would this factor be important?

6. List any changes that appear to be taking place in the stream or reservoir.

D. 1. On data sheet D, sketch an outline map of the area that your group is studying. Show the scale of the map and indicate north. Include both natural and manmade features. Label trees, islands, rocks, trails, roads, or any nearby buildings. Make the map as detailed as possible. Compare the map to a map of the entire reservoir if one is available.

2. Carefully measure the water depth at various places and record these measurements on the map. A long pole and weighted string may be needed to obtain these figures. Remember to give metric, then standard, measurements. Record the average depth at the space provided.

E. 1. Use data sheet E to record the information gained by using the water chemistry test kist. Many of the chemicals in these kits are harmful. Use extreme care. Determine the pH of the water using the pH test kit. Follow the directions in the kit exactly and record the readings on the chart. It would be best to take three readings and average. How would the pH affect plant and animal life in a water community? Did the actual findings match the predictions made in part C?

2. Carbon dioxide tests are to be done next. Again follow the test kit directions exactly. What factors would affect the CO2 content of the water? Again, take three readings and average.

3. Oxygen content can be determined by using the dissolved oxygen test kit provided. Be cautious obtaining the water sample to prevent adding any oxygen as you take it. Follow instructions carefully. Remember to record your results in parts per million (ppm) or milligrams per liter (mg/L). What effect would dissolved oxygen have on organisms?

4. Using a thermometer, determine the air and water temperatures in the habitat. Record both surface and deep water temperatures. How would temperature affect the community? What factors would affect the temperature? Record the temperature in both Celsius and Fahrenheit.

5. Record observations on the turbidity or clearness of the water. Is it clear or murky? How far does the light penetrate? (Determine by lowering a white object on a string into the deeper parts until you can no longer see the object. An instrument called a Secchi disc would provide more accurate data.) How would turbidity affect the organisms?

F. 1. The types of shoreline vegetation have been described. Now try to describe and identify the different plants that grow along the bank. Record on data sheet F. Try to explain why some plants grow there and others do not. Take notes here.

2. Aquatic vegetation is defined as plants growing in water. These may be microscopie algae or plants like water lilies. Try to identify as many of these plants in ther habitat as possible. Note whether they grow in shallow or in deep water.

3. All microscopic life swimming or drifting in the stream water can be termed plankton. Use a plankton tow net* to obtain samples. Tow the plankton net from one end of the area to the other. If this is impossible because of a rocky bottom, the net can be placed under a waterfall for a period of time. Examine the plankton under a microscope** and try to identify the type of organisms. What effect would plankton have on the aquatic community?

---

*A simple plankton net can be made the following way. Remove the cover and bottom of a coffee can. Punch holes in the top edge of it for your tow lines. Insert it into a nylon stocking that has a hole in the toe and a small sample bottle attached by string.

**This could be done in the classroom if more convenient.

Summary

Answers to the following questions are to be included in the group's oral report about its assigned habitat. Discuss these among group members and look up any information not known.

1. How do the three environments differ? Much of this information can be concluded from comparing data sheets.

2. How did the upstream environment differ from that downstream of the reservoir? Were any changes due to natural or man-made influences?

3. Discuss the relationship between water temperature and oxygen content. The warmer the liquid, the less dissolved gas it will hold. A good example is a soft drink. Cold soft drinks keep their "fizz," which is dissolved carbon dioxide, whereas warm soft drinks soon go flat. Likewise, cold water will hold more oxygen than warm water. Explain how oxygen becomes dissolved in water and why a stream falling over rocks would have more dissolved oxygen. Also explain why the reservoir would be warmer that the stream.

4. Catfish and carp need less oxygen than rainbow trout. Why might all three fish be found in a stream but, of these, only catfish and carp in a lake? Research other species of local fish and list them according to their oxygen requirements. (This information can be found in any book about lake ecology or water pollution.) Ask the class which kinds of fish it thinks are more desirable and why.

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT
DATA SHEET A
PHYSICAL CHARACTERISTICS

LOCATION OF HABITAT	WIDTH AND SIZE	AVERAGE DEPTH	TYPE OF VEGETATION	KIND OF ANIMALS	NUMBER OF DIFFERENT ANIMALS	PLANT POPULATION
SITE I						
SITE II						
SITE III						

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT
DATA SHEET B
PLANT AND ANIMAL RELATIONSHIPS

KIND OF ANIMAL		KIND OF PLANT			
COMMON NAME	GENUS	COMMON NAME	GENUS	RELATIONSHIP	GROWTH DEVELOPMENT (POSITIVE OR NEGATIVE CHANGE)
SITE I					
SITE II					
SITE III					

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT
DATA SHEET C-1
HABITAT CHARACTERISTICS

	FOOD CHAIN	EVIDENCE OF POLLUTION	INFLUENCING ABIOTIC FACTORS	EFFECT OF LIGHT	CHANGES
SITE I					
SITE II					
SITE III					

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT
DATA SHEET C-2
FOOD WEB

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT
DATA SHEET D
MAPPING

Draw and label a map diagram of your area.

AVERAGE DEPTH

SCALE

WORKSHEET

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT
DATA SHEET E
CHEMICAL CHARACTERISTICS

pH OF WATER	CO2	DISSOLVED OXYGEN CONTENT	TEMPERATURE		TURBIDITY	EFFECTS ON BIOTIC COMMUNITY
			AIR	WATER		
SITE I						
SITE II						
SITE III						

WORKSHEET

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT
DATA SHEET F
BIOLOGICAL CHARACTERISTICS

	SHORELINE VEGETATION	AQUATIC VEGETATION	PLANKTON
SITE I			
SITE II			
SITE III			

CALCULATING THE POTENTIAL ENERGY OF FLOWING WATER

USE WITH:
Physics
Advanced Physical Science

TIME:
Stream visit and 1 class period

MATERIALS:
Metersticks
Matchsticks
30-meter (100 ft) tape measure
Stopwatch
Topographic map
Worksheets (included)

Objectives

The student will:

1. Measure depths, widths, and velocity (flow rate) for given stream segment.
2. Calculate the rate of flow of volume of a stream.
3. State streamflow values in terms of mechanical energy light.
4. Calculate the potential energy of a stream.
5. Calculate the available power of a stream.
6. State the factors affecting the available power of a stream.

Background Information

Hydroelectric power plants are among the most efficient methods of generating electricity. Efficiencies of 90 percent are not uncommon for large facilities. Smaller facilities usually maintain efficiencies well over 50 percent.

The power obtained over a period of time cannot exceed the potential energy of the flow. Even if a large reservoir is established, the power available will still be equal to the average potential energy in flowing water.

Procedure

1. Select an appropriate stream site and make the necessary arrangements for a class trip.

2. Review the conversion of energy forms in water-powered generation of electricity.

3. Distribute student materials and explain each step of the instructions.

4. It may be more time efficient to divide the class into groups and to divide the data collection tasks among them. The information can then be shared.

5. Supervise the activity. The calculations can be done later in the classroom.

6. Follow with discussion.

Discussion

1. Obtain the volume, flow rate, and head figure for a large hydroelectric facility and calculate the power generated by the plant.

2. Compare the stream studied to the large hydro plant above. Using the calculations done in the activity estimate, how many people might be served in 1 minute? 1 hour? 1 day? (Use 0.4m3/person/day as a typical daily water requirement.)

3. Can small streams such as this one be useful in meeting the nation's energy needs?

Instructions

1. Stake out a measured distance (15 to 30 meters) on the stream bank parallel to the mid-channel line. Record this distance in the data table.

2. Drop 3 or 4 matchsticks into the water upstream from the measured distance and determine the time required for them to pass through this distance. Start timing as the first matchstick enters the measured distance and stop when any one leaves the measured distance. Do this procedure at least three times. Add the results and find the average. Record this figure.

3. Measure the width of the stream at three points along the measured distance. Find the average of the three measurements and record.

4. At three places along the measured distance, measure the depths of the stream at points along a line perpendicular to the bank and crossing the stream. Find the average of the three measurements and record.

5. Survey the area through which the stream flows. Make an estimate of the change in elevation of the stream over a reasonable distance. For accuracy over longer distances, examine a topographic map of the area through which the stream flows. Record.

6. Using the measured distance and the average time, calculate stream velocity (flow rate) using the following formula:

   $$\text{Velocity} = \frac{\text{Distance(Meters)}}{\text{Time (Seconds)}}$$

7. Knowing the flow rate, average depth, and average width of the stream, calculate the volume of water passing a given point in one second using this equation.

   Rate of flow of volume = Flow rate (M/Sec) x Width (M) x Depth (M) = M^3/Sec. Record.

8. Because the density of water is known, and the volume of water flowing past a given point is known, it is possible to determine the mass (and weight) of a given volume of water. One cubic meter of water has a mass 1.00×10^3 kg and a weight of 9.80×10^3 newtons. Calculate each as follows:

   $$\text{Mass water} = \text{Volume in } M^3 \times \text{density of water}$$
   $$= m^3 \times (1.00 \times 10^3 \text{ kg}/m^3)$$

   $$\text{Weight water} = \text{Volume in } m^3 \times \text{density of water}$$
   $$= m^3 \times (9.90 \times 10^3 n)$$

   Record.

9. Allow a volume of water with the weight calculated above to fall through a distance "h". This height is called the water head. The product of weight and this height is the gravitational potential energy (PE) of this volume of water. Students may use estimate of elevation change for "h."

   PE (Joules) = weight (newtons) x head (meters)
   (1 Joule = 1 newton-meter) Note: the unit is a newton-meter.
   Record.

10. The rate of doing work is called power. Work and energy are equivalent units. If the potential energy of a volume of water is known, the power generated by the falling water may be calculated. The power generated depends on three factors:

    1. Weight of water released (step 8)
    2. Head through which water falls (step 9)
    3. Time over which water flows or is released

    $$\text{Power (watts)} = \frac{\text{Weight (newtons) x Head (meters)}}{\text{Time (seconds)}}$$

    (1 watt = 1 Joule/second)
    Record.

11. Check a topographic map for elevation changes that your stream flows through. Use the map to determine head for the stream. Calculate the hydropotential for the stream over 1 minute, 1 hour, 1 day, etc. If a topographic map is unavailable or inappropriate, use an estimate of elevation change. Record.

CALCULATING THE POTENTIAL ENERGY IN FLOWING WATER

DATA TABLE

Measured distance ______________ meters

Time required for matchstick to cover measured distance.

Trial 1 ______________ sec
Trial 2 ______________ sec
Trial 3 ______________ sec

Average ______________ seconds

Width of stream

Point 1 ______________ m
Point 2 ______________ m
Point 3 ______________ m

Average ______________ meters

Depth of stream

Point 1: Depth 1 ________ m, 2 ________ m, 3 ________
Point 2: Depth 1 ________ m, 2 ________ m, 3 ________
Point 3: Depth 1 ________ m, 2 ________ m, 3 ________

Average ______________ meters

Estimate of elevation change

______________ meters

Stream velocity (m/sec) ______________

Rate of flow of volume (m3/sec) ______________

Mass of water (volume x density) ______________

Weight of water (volume x density in newtons) ______________

Potential energy (weight x head) ______________

Power $\frac{\text{(weight x head)}}{\text{(seconds)}}$ ______________

GENERATE YOUR OWN HYDROPOWER

Objectives

The student will:
1. Build a simple hydropower generator.
2. Build a simple galvanometer.
3. Build a water wheel.
4. Measure the electricity generated.
5. Demonstrate how water power is converted to electricity.

USE WITH:
Advanced General Science
Physical Science
Physics

TIME:
1 class period if working in groups of four
2 class periods if working in groups of two

MATERIALS: (for each group)
Compass
Two alligator clips (optional)
Small spool magnetic wire (#28 or finer; insulated)
Cardboard or masonite square base
Glue (optional)
Two 1-inch nails
Two 3-inch nails
Four small nails
Small bar magnet (1 inch)
Two 1-1/2" x 4" metal strips cut from tin can
Electrical tape
Germanium diode (e.g., type 1N34A)
Soldering iron (optional)
Solder (optional)
3" x 5" wood block
Water wheel
Worksheets (included)

Background Information

Millions of tons of water are needed to run a hydroelectric plant. Water held behind dams is released through large gates into a powerhouse at the base of the dam. The large powerhouse encloses heavy equipment used to produce electricity. Water passes through a structure called a "penstock" and into a chamber that swirls the water around a horizontal or sideways adapted water wheel called a turbine. The shaft connected to this turbine drives an electric generator--a large piece of equipment that looks like a motor but actually works in reverse. Large coils of wire inside the generator are mounted on the rotating shaft and, as they turn through magnetic force field, produce electrical energy. The energy generated has a low voltage and is carried in large wires from the generator to the switchyard. Here transformers are used to increase the voltage and send the power into the transmission system. (See diagram 1.)

The model hydropower generator made in this activity works much like hydropower plants for generating electricity. When the propeller (water wheel or turbine) spins, the magnet whizzing past the nail head generates a tiny amount of alternating current (AC) in the coil wound around the nail. The small germanium diode connected across the two nail terminals converts the AC into DC (direct current).

The galvanometer will indicate the small current that has been produced by the generator.

Procedure

1. The day before the activity is to be done, introduce it to the class by:

    A. Describing a water wheel (turbine).
    A turbine is a device that has a central drive shaft fitted with curved vanes which whirls by the pressure of water, steam or gas. A water wheel uses water instead of steam or gas.

    B. Defining a galvanometer.
    A galvanometer is an instrument that measures minute electric currents.

    C. Describing how a galvanometer works.
    A galvanometer is made of a compass wound with electric wire. As current is passed through the wire, the compass needle will be deflected toward the east-west axis.

    D. Defining generator.
    A generator is a machine by which mechanical energy is changed into electrical energy; a dynamo.

    E. Defining hydrogenerator.
    A hydrogenerator is a machine by which mechanical energy in the form of water power is converted to electrical energy.

2. Hand each student a water wheel handout sheet.

3. Assign as homework making a water wheel (turbine). (You may choose to build in class.)

4. Distribute instructions and explain activity.

5. Follow with discussion.

Discussion

1. How may minute quantities of electricity be detected?

    Movement (deflection) of the compass needle occurs as slight electrical currents travel through the wire of the galvanometer.

2. Describe how the apparatus used in this activity qualifies as a generator.

   If a generator is a machine by which mechanical energy is converted to electrical energy, then this water wheel apparatus, which converts the energy of moving water to electrical energy, is a generator.

3. What type electricity (AC or DC) does your generator produce?

   AC.

4. What type of electricity does a galvanometer detect?

   DC.

5. What is the purpose of the germanium diode?

   It converts AC electricity to DC electricity.

6. Did your hydrogenerator produce electricity? How much?

7. Is there a stream or creek near any students' homes? Could the stream(s) be used for hydroelectrical power? Why or why not?

8. Describe two adaptations that could be made to this hydrogenerator to make it use other forms of power.

   The blades on the turbine could be longer and less curved so that it could be used for wind power. The turbine could be modified to a piston type to be used in steam-generated power.

9. The following are suggestions for building upon this activity. Some are especially appropriate as enrichment.

   a. Different types of water wheels may be built and their effectiveness tested. Check reference books for other designs.

   b. Vary the velocity of the water and repeat the exercise. Compare results.

   c. Add suspended solids like silt (dirt) to the water.

   d. Compare the use of hot and cold water to run the water wheel.

   e. Build a model town complete with electrical light bulbs. Check to see if the hydrogenerator will supply enough electricity for the model town.

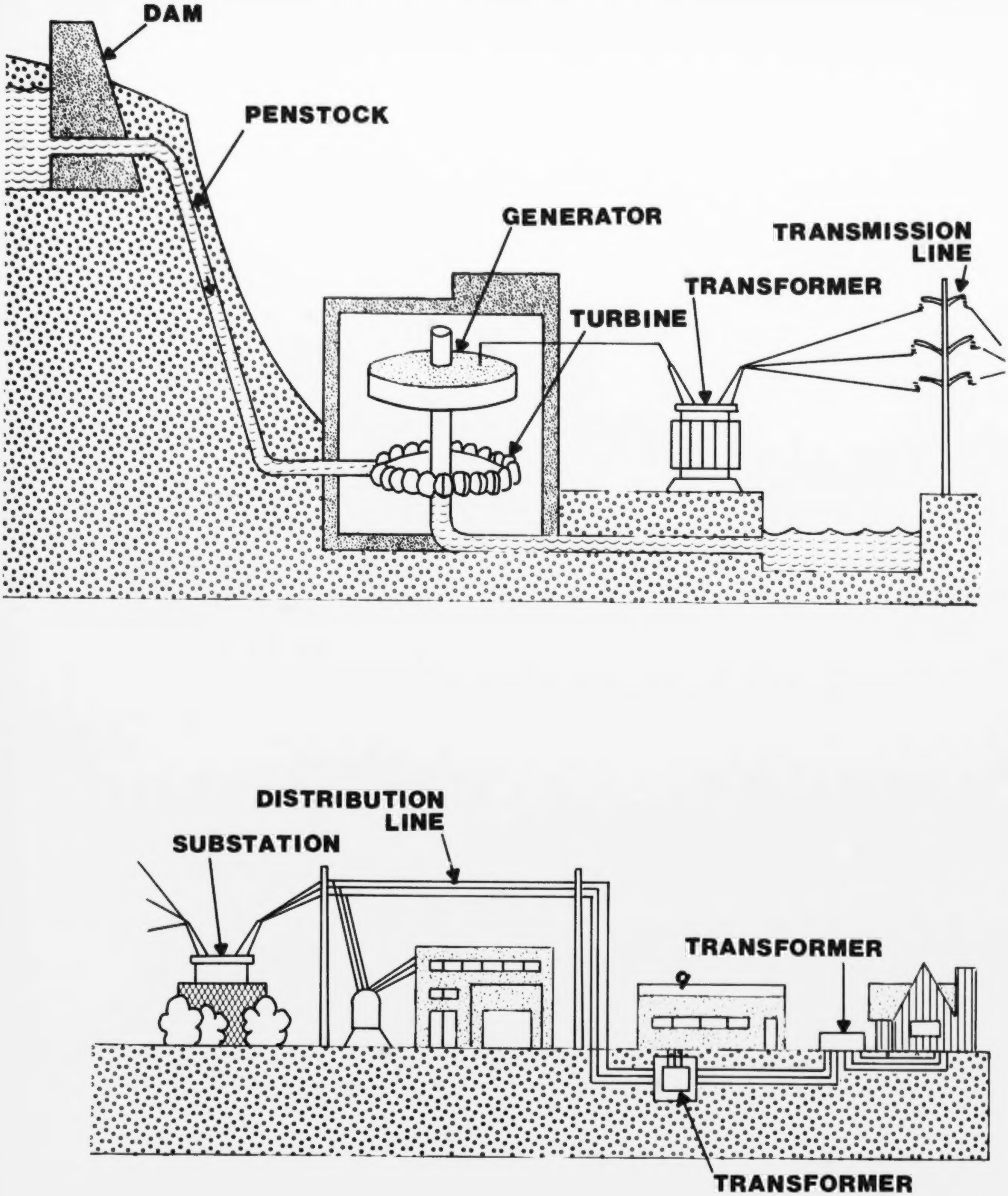

DAM
PENSTOCK
GENERATOR
TRANSMISSION LINE
TRANSFORMER
TURBINE
DISTRIBUTION LINE
SUBSTATION
TRANSFORMER
TRANSFORMER

Diagram 1

GENERATE YOUR OWN HYDROPOWER

Instructions

1. Build a galvanometer. (See diagram 2.)
    - a. Place a compass on a base.
    - b. Wind magnetic wire around the north-south axis about 100 turns.
    - c. After winding the coils of wire, twist the free ends a few times to prevent unwinding.
    - d. Connect the free ends to the two alligator clips. This step is optional. You may connect the wires directly to the nails where the diode is located on the hydropower generator apparatus. If using the alligator clips, you may want to drip white glue over the coil of wire to keep it in place.

The galvanometer is now complete. Whenever electricity flows through the coil, the compass needle will be deflected toward the east-west axis.

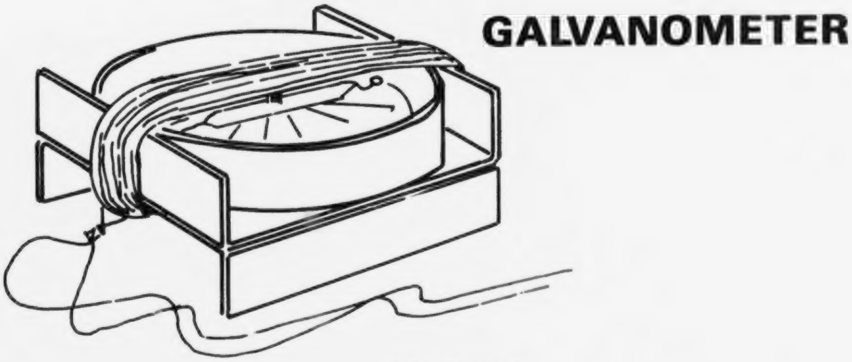


DIAGRAM 2

2. Build a hydropower generator (See Diagram 3.).
    - a. Wrap 1,000 turns of magnetic wire around one of the large nails. The coil should be 2 inches long, measured from the head end. Leave a few inches of wire for connections. Twist them so they will not unwind.
    - b. Drive this nail into the center of the wood block.
    - c. Drive in the two smaller nails. Refer to diagram 3.

HYDROGENERATOR

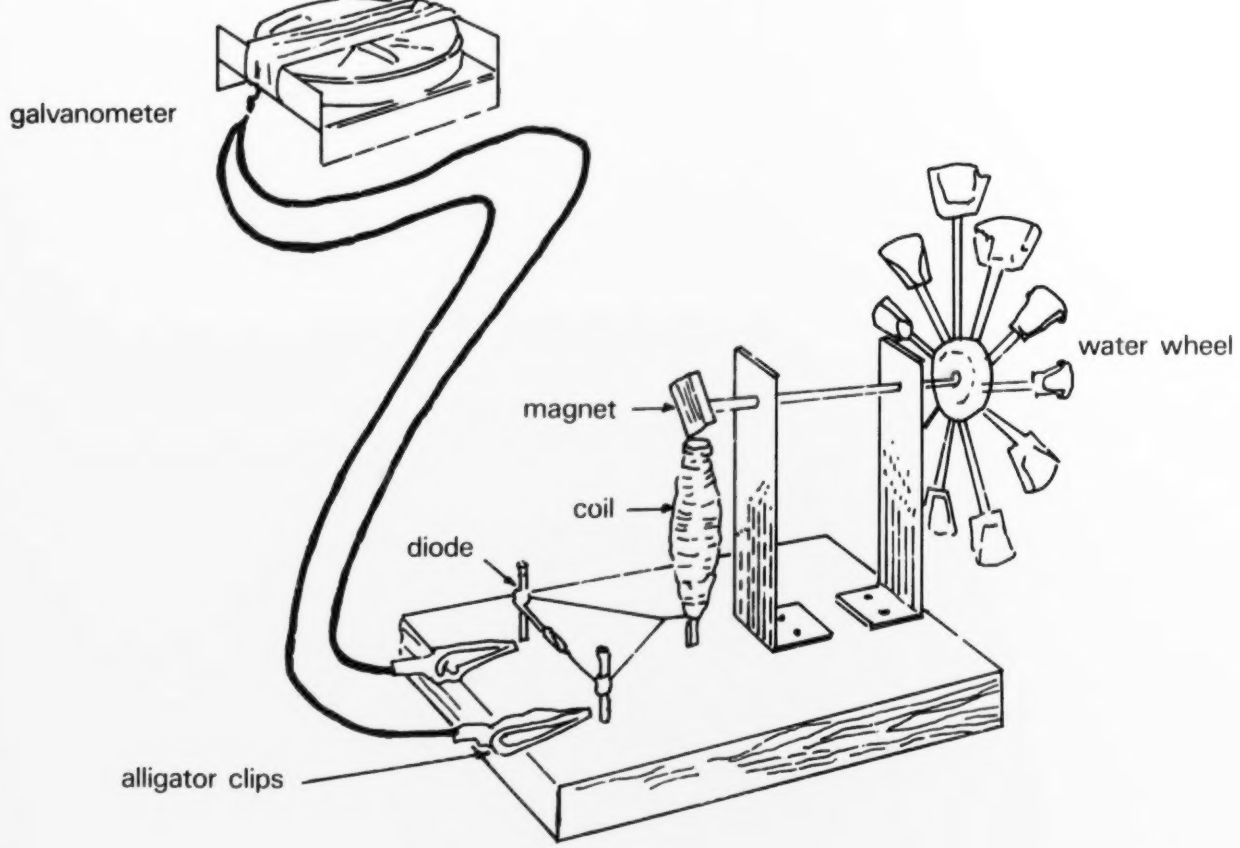

galvanometer
water wheel
magnet
coil
diode
alligator clips

Diagram 3

   d. Scrape the enamel insulation off the ends of the coil wires.
   e. Wrap the ends around the nail heads.
   f. Hook the diode across the nails and make all connections secure. (Soldering is optional.)
   g. Connect the bar magnet to the head of the other large nail. The magnet should be centered on the head of the nail. If using glue, give it plenty of time to set. This will be the water wheel shaft.
   h. Support the shaft with two tin can strips. Fold them in half lengthwise for added stiffness. Bend out about three-quarters of an inch at the ends for the base. Nail them to the wood block in line with the large nail.
   i. Decide how high the shaft holes should be. Locate the holes so the magnet ends are close to the upright nail head but will not prevent the shaft from spinning freely. Make the holes for the shaft.
   j. Insert the shaft in the supports until the magnet is directly over the nail head. Two collars of electrical tape will keep the shaft in place.
   k. Drill a hole in the water wheel (turbine) so that it fits snugly on the nail.
   l. Fit the water wheel onto the shaft.

3. Test the hydrogenerator.
   a. Connect the galvanometer's alligator clips (or wire if not using alligator clips) to the two nail terminals.
   b. Keep the compass about a foot away from the magnet.
   c. Line the galvanometer coil up with the compass needle.
   d. Hold the water wheel at the edge of the sink and run a stream of water over the wheel.

As the wheel turns, it will power the generator and a small current will be detected on the galvanometer. When the shaft turns, the compass needle will be deflected. This demonstrates that electricity is being produced from the hydrogenerator.

GLOSSARY

Abiotic factors:	The non-living factors in an environment such as light, temperature, water, pH, space, and chemical elements.
Alternating current:	A.C.; current that changes its direction at regularly recurring intervals.
Biotic factors:	The living part of the environment such as all plants, animals, and microscopic life.
Carbon dioxide:	(CO_2) A heavy colorless gass that dissolves in water to form carbonic acid, is absorbed by green plants in photosynthesis, and is used in the carbonation of beverages. It is also given off by the combustion and decomposition of organic substances.
Direct current:	D.C.; current that flows in one direction only.
Dissolved oxygen:	(DO); The amount of oxygen dissolved in water or waste.
Flow rate:	Velocity of a stream or the measure of a volume of water passing a given point in some unit of time. The unit for flow rate in the SI system of measurement is meter/second (m/s).
Flume:	An inclined channel for conveying water (as for power).
Galvanometer:	An instrument that measures minute electrical currents.
Generator:	A machine by which mechanical energy is changed into electrical energy; a dynamo.
Gristmill:	A mill for grinding grain.

Habitat:	The area where an organism lives and carries on its daily activities involved in its niche. The "address."
Hydropotential:	The potential energy available in a given amount of flowing water.
Hydrogenerator:	A machine by which mechanical energy in the form of water is converted to electrical energy.
Mass:	Amount of matter present in a sample. The unit of measurement for mass in the SI system is the kilogram (kg).
Millrace:	A canal in which water flows to and from a millwheel; the current that drives the wheel.
Niche:	The role an organism plays or performs in its daily activities. The "profession" of the organism.
Parts per million:	(PPM); A unit of measure used in chemical testing which indicates the parts by weight in relation to one million parts of water. One part per million is equivalent to 8.3 pounds of a material in one million gallons of water. This may sometimes be written as milligrams per liter.
pH:	This is a scale based on the hydrogen ion concentration by which water and other substances are measured to determine if they are acid, neutral, or alkaline. The midpoint of the scale is pH 7.0. Readings from 0.0 to 7.0 are acid, and the lower the pH value the more strongly acid the material. Readings 7.0 to 14.0 are alkaline, and the higher the reading the more strongly alkaline, material. pH indicators react with water samples to give different colors at different values. These colors can be calibrated and duplicated in the form of permanent color standards.
Potential energy:	Energy that is the result of position. The unit of measurement for energy in the SI system is the joule (j). One joule is equal to one newton of force acting through a distance of one meter. $1\ j + 1\ kgm^2/sec^2$

Power:	The time rate of doing work. The unit of measurement for power in the SI system is the watt (w). One watt is equal to one joule per second. 1 w = 1 kgm^2/sec^3
Reservoir:	An artificial lake where water is collected and kept in quantity for use.
Sluice:	An artificial passage for water fitted with a valve or gate for regulating the flow of a water wheel.
Topographic map:	A map showing the configuration of a surface including its relief.
Turbine (water wheel):	A device that has a central driving shaft fitted with curved vanes which whirls by the pressure of water, steam, or gas. A water wheel uses water instead of steam or gas.
Turbidity:	The reduction of transparency of a liquid due to the scattering and absorbing effect of light by suspended particles.
Undershot:	A water wheel turned by the weight of water flowing from above.
Velocity:	The quickness of motion; speed or rapidity.
Water wheel:	A wheel made to rotate by direct action of water; a wheel for raising water.
Waterhead:	The change in elevation or the height through which a volume of water will fall.
Weight:	The measure of gravitational force acting on a substance. The SI unit of weight is the newton. One newton is equal to one kilogram of mass being accelerated at one meter per second squared ($1 n = 1 kg\text{-}m/sec^2$).
Work:	A force acting through a distance. Work has the same SI unit as potential

REFERENCES

Bureau of Reclamation. Water Measurement Manual. Washington, D.C.: Government Printing Office, 1967.

Electric Power Research Institute. Electricity: Today's Technologies, Tomorrow's Alternatives. Los Altos, CA: ERRI (Distributed by W. Kaufman.), 1982.

Encyclopedia Britannica. Chicago: Encyclopedia Britannica, Inc., 1974.

Energy Policy Project of the Ford Foundation. A Time to Choose: America's Energy Future. Cambridge, MA: Ballinger Publishing Company, 1974.

Fowler, J. W. Energy - Environment Sourcebook. 2 vols. Washington, D. C.: National Science Teachers Association, 1975.

Gabel, M. Energy, Earth, and Everyone. New York: Anchor Press, 1980.

Halacy, D. S. Earth, Water, Wind, and Sun: Our Energy Alternatives. New York: Harper and Row, 1977.

Merrill, R. and T. Gage. Energy Primer: Solar, Water, Wind, and Biofuels. New York: Dell Publishing, 1978.

Mervine, K. and R. E. Cawley. Energy-Environment Materials Guide. Washington, D. C.: National Science Teachers Association, 1975.

Moffet, M. Built for the People of the United States: Fifty Years of TVA Architecture. Knoxville: University of Tennessee, 1983.

Morris, D. J. Be Your Own Power Company. Emmaus, PA: Rodale Press, 1983.

Mother Earth News. A Handbook of Homemade Power. N.p.: Baxter Books, 1974.

National Academy of Sciences. Energy for Rural Development: Renewable Resources and Alternatives Technologies for Developing Countries. N.p.: NAS, 1976.

National Archives and Record Services. National Audiovisual Center (Catalog of films). Washington, D. C.: General Services Administration, n.d.

Northern States Power Company. Hydropower and the Second Century. Minneapolis, MN: NSPC, n.d.

Tennessee Energy Office. Home Energy Audit Worksheet. Nashville, TN: TEO, n.d.

Tennessee Valley Authority. Electricity. Knoxville: TVA, 1983.

___. *Facts About TVA Dams and Steam Plants*. Knoxville: TVA, 1984.

___. Division of Power Utilization. *Energy Primer*. Chattanooga: TVA, n.d.

U.S. Department of Energy, Technical Information Center. *Award-Winning Energy Education Activities*. Oak Ridge, TN: USDOE, n.d.

___. *Classroom Science Films* (Catalog). Oak Ridge, TN: USDOE, n.d.

___. *Energy Conservation in the Home*. Oak Ridge, TN: USDOE, n.d.

What Everyone Should Know About Hydropower. South Dunford, OH: Channey L. Bete Company, 1984.

COAL

OVERVIEW

There is enough potential heat in a pound of coal to brew more than 100 cups of coffee, and there may be more than 2 trillion tons of coal deposits in the United States (ten times as much as all the presently known coal reserves).

Coal is an organic rock composed of the decayed and compressed remains of plants that lived in prehistoric swamps and bogs. This organic debris gradually sank and was buried by sediment. Biochemical decomposition and geological processes slowly transformed and fossilized this compacted mass of organic material into various forms of coal. The four different types of coal are lignite, subbituminous, bituminous, and anthracite.

In the Tennessee Valley region, coal is the most commonly known fuel and was responsible for over one-half of electrical production in 1984. Bituminous coal is the only type of coal used in the Tennessee Valley Authority's 12 coal-fired facilities. More than 31 million tons of bituminous coal were burned in the Tennessee Valley in 1985, at a generation cost of 2.172 cents per kilowatt hour (kWh).

Coal deposits are found in abundance in the Tennessee Valley, primarily in Kentucky and Virginia. Coal is brought from the ground by either surface mining or underground mining. Surface mining is usually limited to coal deposits within 100 to 200 feet of the earth's surface. Most of the coal below 200 feet is mined underground.

Until World War I, coal was the leading source of energy in the United States. As the use of coal replaced wood, so hydro, oil, and natural gas began to replace coal. With the oil embargo in the mid-1970s, the country began to turn again to its most abundant fossil fuel, coal. Since 1950, when construction of coal-fired plants began, coal has been one of the three major sources of energy used by TVA. By 1970, the coal-fired plants were producing six times as much electricity as the hydroelectric plants.

The use of coal has caused some environmental problems. Unreclaimed land from surface mining, water pollution, acid rain, and air quality are major environmental concerns with coal. Most of these problems are approaching cost-effective solutions because of new technologies and also because of such stringent laws as the Clean

Air Act and the Clean Water Act. Acid rain is one of the most complex and confounding environmental effects produced by a manmade system. There is disagreement between scientists and politicians about the chemical processes, the effects on the environment, and what should be an effective and responsible approach to remedying the problem.

Coal is a major energy source for production of electricity both in the Tennessee River Valley and nationally. Research will continue and may even increase, thus offering solutions to the problems associated with coal use. However, because of its abundance and its relative low cost, coal will continue to be a major energy source in the future.

COAL AND GEOLOGIC TIME

USE WITH:
Earth Science
General Science
History
Social Studies

TIME:
1-3 class periods

MATERIALS:
Meter stick
Millimeter scale
Adding machine paper or wrapping paper cut into narrow strips
Pencils (black and red)
Worksheet (included)

Objectives

The student will:

1. Develop a visual representation of geologic time.
2. Perform calculations and measurements while developing an accurate time scale.
3. Visually pinpoint the eras of the formation of coal in relation to all of geologic time.

Background Information

Scientists believe that the earth has existed for about 4.5 billion years. Geologists have devised a geologic time scale in which the entire history of the earth is divided into large eras on the basis of the life or types of life which are dominant at that time. Divisions of time are usually marked by a break or change in the types of fossil forms which dominate the era or in the type of rock which commonly occurs. Radioactive dating is one method used to determine the age of the earth.

Coal is one of the rock formations that geologists study to find clues from the past. Coal is an organic rock composed of the decayed and compressed remains of plants that lived in prehistoric swamps and bogs. This organic debris gradually sank and was buried by sediment. Biochemical decomposition and geophysical processes slowly transformed and fossilized this compacted mass of organic material into various forms of coal. The four types of coal are lignite, subbituminous, bituminous, and anthracite.

In comparison with the age of the earth, the span of man's existence on the earth is only a brief moment. It is difficult to visualize the vastness of geologic time. We think that a man who lives to be 80 is old, and a man of 100 is a rarity. Yet, when we try to compare this length of time with the age of the earth, we find it almost impossible. How long is a billion years? Many people have difficulty grasping the concept of geologic time. To visualize billions, millions, or even thousands of years is difficult. What is needed is a scale which will allow us to convert large periods of time into more understandable units.

Procedure

In this exercise, the student will make a graphic model that will aid in the understanding of the age of the earth, as well as identify the periods of coal formation relative to the earth's age.

Instead of working in years, the student will work in seconds, with one second being equal to one normal year. In this way, the following table represents some major events of geological time.

1 second	=	1 year	Event
0 sec		-----	Now
17 sec		-----	First men on the moon
47 sec		-----	World War II
125 sec		2 min 14 sec	Civil War
494 sec		8 min 14 sec	Columbus
1,986 sec		33 min 6 sec	The year 0
4,982 sec		1 hr 23 min	Writing invented
86,400 sec	=	1 day	
259,200 sec		3 days	Fire first used by man
2,073,600 sec		24 days	First man-like animals
2,592,000 sec		30 days	First stone tool
31,536,000 sec		1 year	Peat coal formed
126,144,000 sec		4 years	Extinction of dinosaur
157,680,000 sec		5 years	First birds
220,752,000 sec		7 years	First dinosaur
283,824,000 sec		9 years	First reptile
409,968,000 sec		13 years	Anthracite coal forms
599,184,000 sec		19 years	First fossils appear
630,720,000 sec		20 years	Cambrian period
1,261,440,000 sec		40 years	First animal (jelly fish)
2,049,840,000 sec		65 years	First plants (algae)
2,522,880,000 sec	=	80 years	
3,311,280,000 sec		105 years	Oldest known rock

1. Distribute the worksheet to students. Discuss and compare the seconds to years.

2. After comparing seconds to years, have the students construct a time-line-tape which also helps in visualizing geologic time. On this scale, let 1 mm equal 1 million years (1:1,000,000). Use the following procedure to continue the activity.

a. Cut a piece of adding machine paper 5 meters long.

b. One cm from the left end of this strip, draw a straight line across the strip.

c. Print the word "NOW" along this strip.

d. Starting at the "NOW" line, measure four intervals of one meter each and make a similar mark at each interval.

e. The first line has been labeled "NOW," the next should be labeled "2 billion years ago," and so on until all are labeled.

f. Measure to find "4.5 billion years ago."

g. Mark this point and label it "earth's beginning?".

h. Now, write the events that you have noted from the table. You may need to develop a chart first for transforming time measurements into distance measurements. (Remember that 1 sec = 1 year, and also that 1 mm = 1 million years; therefore 1,000,000 sec = 1 mm, and in the same way 1,000,000,000 sec = 1 M.)

3. What other events could be placed on the geologic table? Search through earth science text books for other such geologic time tables. Convert years to seconds by multiplying by 31,536,000 and relate this information to the time-line.

b. Divide the class into working groups and assign each group a section of the time scale as a research topic. Each group should develop its assigned topic and then present an expanded time scale to the class. Each group can present its section in chronological order, thus providing a broad overview of geologic time to the entire class. These data can be scrolled into wooden handles for easy storage and transport and used to present this information to other classes and groups now and into the future. Each group may center on coal during its assigned time period; if so, more groups may be assigned to more recent times to detail the use of coal during world industrialization. One group may be assigned to the future and should use the preceding groups' work to predict the uses of coal in the near and far future.

Discussion

1. What can you say about the formation of coal when compared to all of geologic time? About the development of man?

   According to the data in the table, geologic time covers an unknowable large period of time. Compared to this, the formation of coal occurred relatively recently, and the development of man is even more recent.

2. Describe the conditions necessary for coal to form. Do these exist today? Is coal being formed now?

   Sub-tropical conditions which can support the luxuriant growth of vegetation, plus a bog or swamp habitat to exclude oxygen, are required; heat and pressure (and time) below the crust of the earth are required to form the more compacted forms of coal. Of course these conditions exist today. Commercial peat extraction is utilized as an energy source in various nations, but this represents a very small portion of the world's energy use.

3. Why is coal referred to as a fossil fuel or as "buried sunshine"?

   Coal contains the fossilized remains of plants, and plants depend directly upon sunlight as an energy source for growth.

4. Why do we include a question mark in the label "earth's beginning?"?

   Science depends upon observable data for the formation of conclusions. The further the observer is from the event (in space or time), the less reliable is the data collected and so the less solid is the conclusion reached. In cases like this, a guess or a rough approximation is better than no conclusion at all. A best guess can be tested and modified and, we hope, will come closer and closer to the "truth."

5. Is coal considered a renewable resource? Defend your response.

   Man's life span, and even several human generations, is but an instant compared to the periods of time necessary to build up any sort of substantial deposit of coal. Because of this, coal is considered nonrenewable.

Resource

Fischer, A. G. Invertebrate Fossils. New York: McGraw-Hill, 1952.

1 second	=	1 year	Event
0 sec		-----	Now
17 sec		-----	First men on the moon
47 sec		-----	World War II
125 sec		2 min 14 sec	Civil War
494 sec		8 min 14 sec	Columbus
1,986 sec		33 min 6 sec	The year 0
4,982 sec		1 hr 23 min	Writing invented
86,400 sec	=	1 day	
259,200 sec		3 days	Fire first used by man
2,073,600 sec		24 days	First man-like animals
2,592,000 sec		30 days	First stone tool
31,536,000 sec		1 year	Peat coal formed
126,144,000 sec		4 years	Extinction of dinosaur
157,680,000 sec		5 years	First birds
220,752,000 sec		7 years	First dinosaur
283,824,000 sec		9 years	First reptile
409,968,000 sec		13 years	Anthracite coal forms
599,184,000 sec		19 years	First fossils appear
630,720,000 sec		20 years	Cambrian period
1,261,440,000 sec		40 years	First animal (jelly fish)
2,049,840,000 sec		65 years	First plants (algae)
2,522,880,000 sec	=	80 years	
3,311,280,000 sec		105 years	Oldest known rock

UNITED STATES COAL DEPOSITS

USE WITH:
Earth Science
Social Studies
Geography
Economics

TIME:
1-2 class periods

MATERIALS
Colored pencils
Map of U.S. coal deposits

Objectives

The student will:

1. Research independently to gather information about primary transportation networks in the U.S.
2. Determine and then indicate on a U.S. map the major industrial regions and also the twenty largest urban areas.
3. Synthesize the above information in relation to the information provided in the map entitled "U.S. Coal Deposits" to develop a basis for understanding the current relation between coal as an energy source and our industrialized society.

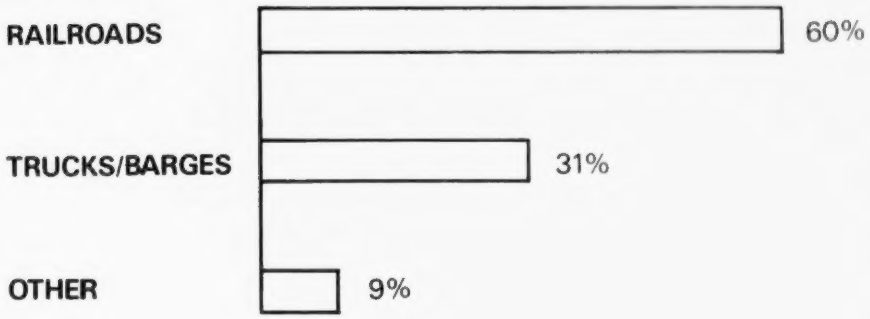
Background Information

Coal has been found on every continent on earth. If it can be recovered profitably, we consider it to be a coal reserve. It is estimated that we have demonstrated reserves of over 700 billion short tons of coal in the world. The U.S. has approximately 35 percent of the world's coal reserves, the USSR has 25 percent, and China about 15 percent. The remaining amount is shared by Australia, Canada, Great Britain, India, Poland, South Africa, and West Germany.

The enclosed map illustrates the locations of major U.S. coal deposits. Note that about half of our coal reserves are located in the eastern region, and that most anthracite deposits and more than 75 percent of the bituminous deposits are also in that area. The reserves in the western part of the U.S. are mostly subbituminous coal and lignite. Having a large coal reserve would not mean very much without the ability to produce and transport it to market efficiently and economically. The U.S. has one of the world's most advanced coal technologies, and large-scale mechanization of the coal industry has resulted in an ability to supply vast quantities of coal to a variety of markets, both at home and abroad.

An important link in the coal distribution chain is the transportation network. About 88 percent of domestically marketed coal is moved long distances by railroads, barges, and trucks. The remainder is transported shorter distances by trucks or conveyor systems for use in "mine mouth" electric power plants when the coal mine is located nearby. Coal slurry pipelines are also feasible in some locations. Coal for the overseas market is shipped from U.S. ports in large ships called colliers. In 1982, about 13 percent of the U.S. coal production was exported.

The major forms of transport of coal from mine to our domestic market



Procedure

1. Provide each student with a copy of the map entitled "U.S. Coal Deposits." Divide the class into pairs.

2. Have one student in each group research the U.S. transportation system and the other research the U.S. urban and industrial regions. Transportation should include types of transport, efficiencies of each, and major routes. Urban and industrial regions should include the 20 major urban/industrial cities, their populations, industry types (coal-related), recent growth or decline, cost of living, etc.

3. The pair should then work together. Draw the transport system and the industrial areas on the provided map of coal deposits.

4. Using this map, discuss the relationships between coal, transport, and industrial growth. Ask the students: What observations and inferences can you make about the U.S. as to:

   a. Coal deposits?
   b. Transportation networks?
   c. Industrial centers?
   d. Urban areas?

   (Observations are first-hand experiences of things or events; inferences are judgments about observations or events.)

5. Relate the information collected in this activity to the current U.S. population shift from the East to the Sunbelt and Midwest. Ask the students: What are the implications of this for coal use in the U.S. and in the Tennessee Valley region?

Discussion

1. How are these factors related? Interrelated?

   During colonization and expansion in the U.S., urban centers developed near rivers or seaports because of transport needs. Also, the industrialization of this nation caused those areas near usable coal deposits to develop more rapidly. This caused populations to grow as people came to fill the new jobs created. These factors show the relationships of the locations of current urban industrial areas and the transport web that connects them. Of course, some areas developed for other reasons, and these should also be considered and discussed by the class. It could also be interesting for the class to discuss future expectations concerning transport networks, urban growth, and industrial centers, as our economy shifts from industrial to service and information industries.

2. What technology do we need to develop to better utilize our coal reserves?

   Coal transport (slurry pipelines, gasification, etc.); coal extraction techniques (efficient and environmentally safe); coal burning (increasing burning efficiency, removal of air pollutants, increasing efficiency of small coal furnaces).

3. How does the availability of coal directly affect our overall economy?

   Consider coal uses in our economy (to production of electricity and direct use by industry, business and homes). Then consider any alternative energy sources that could take coal's place. Any replacement source would be significantly more costly and would result in an economic price spiral.

4. Explain why coal is a major source of energy for the U.S. today. What are its advantages? Disadvantages?

   Coal is a major source of energy due to executive decisions (particularly by the Federal Government) made years ago to promote coal use. This decision was made because the U.S. has substantial recoverable deposits of coal that can last up to 200 years at currently projected rates of use. Also, coal-fired technology is fairly well developed and can be used in large centralized power production plants (congruent with our current energy electricity distribution network). The environmental problems associated with coal use are somewhat less problematic than those associated with other energy sources. Air pollution from burning coal can be controlled; the question is what levels of emissions are to be allowed at what amount of capital expense.

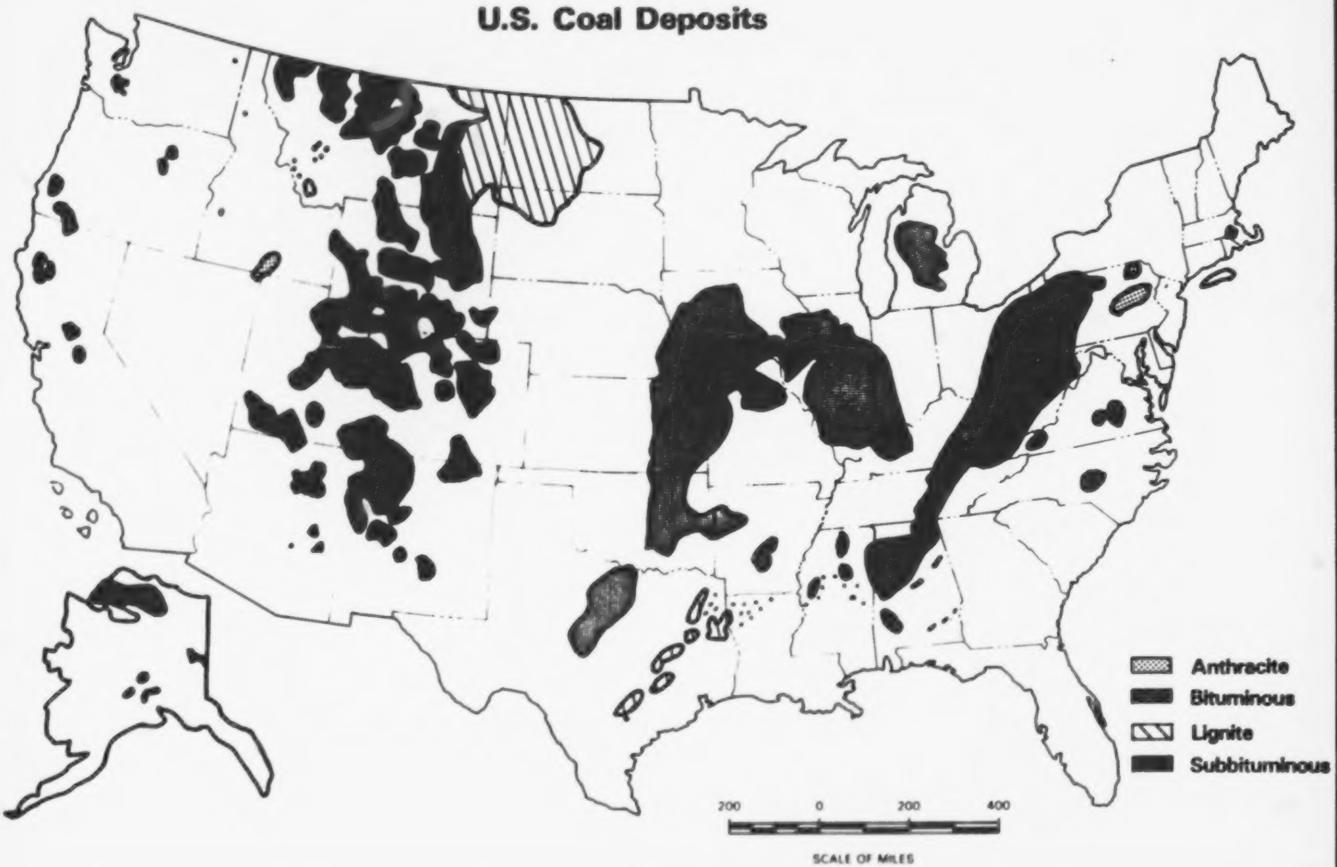
5. What observations and inferences can you make about the availability of coal in the Tennessee Valley?

   The recent increases in the use of coal in electric power generation by TVA reflect a decision to rely on coal (especially our locally available coal) more and more. Again, this is due to cost, efficiency, reliability, technology, and other factors that make coal the best short-term energy option.

Resource

An American Asset. (28-minute film.) New Hyde Park, New York: Modern Talking Picture Services, Inc., n.d.

Kirchen, W. Our Natural Resources. N.p.: Interstate Printers and Publishers, 1982.



U.S. Coal Deposits

▨ Anthracite
■ Bituminous
▧ Lignite
■ Subbituminous
200
0
200
400
SCALE OF MILES

RECOVERING, PROCESSING, AND UTILIZING COAL

USE WITH:
Earth Science
Social Studies
General Science
History

TIME
1-2 class periods

MATERIALS:
Assorted colored felt tip makers or pencils
Newsprint or posterboard
Masking tape

Objectives

The student will:
1. Research the history of recovering, processing, and utilizing coal and provide the information gained to a small cooperative group.
2. Illustrate the information from the research in a class poster-chart.
3. Assist in presenting to the class his/her group's summary concerning recovery, processing, and utilization of coal.

Background Information

There is evidence that the Chinese were the first to use coal approximately 3,000 years ago. The use of coal is also documented in the Bible; Proverbs 6:28 indicates that King Solomon used coal. There is evidence in Wales that coal was used for funeral pyres by Bronze Age people; the Romans also used coal for many purposes.

In what was to become the United States:

a. There is evidence that coal was used by the Indians. The first recorded usage was in Virginia in 1702. The earliest commercial mining was in 1750 from the James River coal field near Richmond. The first anthracite discovery was in Pennsylvania in 1728, but its first actual usage was not until 1769.

b. Coal consumption had an extremely slow start because the abundant forests supplied nearly all the needed fuel. Then too, charcoal was cheaper and better known than coal.

c. When coal consumption succeeded that of wood, the development of railroads, steel mills, and other large consumers of fuel was such that coal mining became increasingly important. The industrial development increased after the Civil War and the consumption continued to climb rapidly until World War I.

In recovering or mining coal:

a. All coal was hewed by hand using pick and bar in the early mines. It was then shoveled into baskets, boxes, or wheelbarrows and dragged by man-power (women included) to the outside. Later, cars were developed but were still drawn by humans. As time went on, dogs, ponies, or horses did the pulling of cars over rails. Eventually, black powder was used to blast down the coal, but the drilling and cutting were still done by hand. The first electric locomotive for underground use was developed in 1883.

b. Modern mechanization of operations, which started before 1900, involves punching machines and chain-type cutters for undermining the coal seam before blasting, and electric and compressed air locomotored and continuous mining machines.

c. During the 1920s, loading machines were successfully used in mines.

d. In the 1930s, rubber-tired shuttle cars began the conversion from track-mounted loaders and cutters to off-track types utilizing crawlers or rubber tires.

e. After World War II, tungsten carbide bits were introduced for drilling and cutting machines and permitted continuous mining. These bits made it possible to drill holes in rocks to support the roof by bolting, replacing posts and crossbars and thus affording more clearance for man and machine to operate. This also provided dustless clean-up and increased safety. No mining innovation in the past thirty years has been more important than roof bolting.

f. The shuttle car is being phased out in some mines through the increasing use of portable conveyor belts. Attached behind a continuous miner, these afford almost continuous transportation of coal to the fixed conveyor system.

g. Another significant development is the use of the "scoops" for loading and hauling in the seams, clearing the floor, and also carrying men and supplies.

Today coal is mined in several ways, including:

a. Surface mining: This procedure is used when coal beds lie close to the surface in the side of a hill or mountain. The opening into the mine is made directly into the coal seam.

b. Slope mines: In this type of mine, an inclined opening leads from the surface to the coal seam or seams.

c. Shaft mines: The coal is reached by a vertical opening from the surface to the coal seam or seams.

In modern mining systems, underground mining is usually classified according to the type of equipment used, such as:

a. Conventional: The coal face is cut and the block (or blocks) outlined is then drilled. The drilled holes are usually charged with explosives, and the coal is gathered up by a loading machine. Ventilation is established and the process is repeated.

b. Continuous: A single machine called a "continuous miner" breaks the coal mechanically and loads it for transport. Roof supports and ventilation are assured, and then the coal face is ready for the next cycle.

c. Longwall: Large blocks of coal are outlined and completely removed in a single operation.

Procedure

1. Divide the students into three groups and have each group focus on recovery, processing, or utilization of coal in the U.S. Using a chart format similar to the one below, have students research and list the events, procedures, and technological advances that have been made in each of these three areas in chronological order.

Recovery/Mining	Processing	Utilization
1.	1.	1.
2.	2.	2.

Also consider such other factors as:

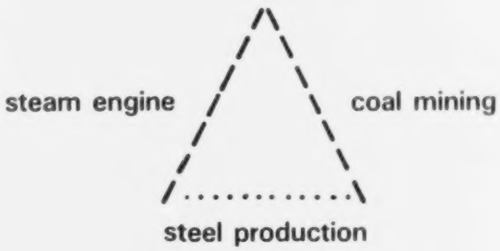
a. The availability of transportation
b. Employment
c. Economic variables
d. Environmental conditions (i.e., benefits from reclaimed land, etc.)

2. Next have each group plot these events, procedures, and technological advances on a poster-chart. Illustrate each event on the poster-chart. The table below will help you to begin.

Recovery/Mining							
Processing							
Utilization							
	1700	1750	1800	1850	1900	1950	2000

Display the poster-chart developed by the class.

3. The steam engine provided energy for transportation in this early period because it could be mounted on a platform. The history and use of the steam engine is closely related to the use of coal. In fact, one of the first uses of steam engines was to pump water out of coal mines. Also, coal was needed for the production of iron, and iron is used to make steam engines, and so the following circular relationship existed:



4. Consider the role of coal in the industrialization of the U.S. and of the Tennessee Valley region, based upon the diagram above. Ask the students what role they think coal will play in the future development of the Valley region.

Discussion

1. What can we extrapolate from your poster chart?

2. How are the factors related? How do they affect each other?

   Like all of our industrial processes, there is a tendency to use less labor and more energy-dependent machinery. Developments or technological advances made in society (invention of the steam engine; development of electricity, explosives, etc.) carry over into all of the three areas and have different impacts on each. Look for concurrent events on the time chart that may have an external cause. Also, such economic factors as establishment of minimum wages, war, depression, etc., should be considered as to how these affect mining, processing, and utilization and should be discussed. Recent environmental protection laws (mine contour recovery, mine spoils water pollution, air pollution) perhaps have had a simultaneous impact on all three aspects of coal use.

3. What other factors could you consider?

4. What factors could you project for the future?

   Eventually, as petroleum deposits grow smaller, coal may become more valuable as a source of liquid petroleum products for lubrication and for synthesis of various materials including nylon, plastic, and polyester. The price of coal should rise if there is an expanded market, especially for high-quality, "pure" coal. Eventually, the burning of fossil fuel will be viewed as wasteful, like burning dollar bills to stay warm. Our grandchildren will ask us why we were so foolish and why we didn't think that they would need it for more noble uses.

   Other power sources may take over coal's current role, and farm-grown vegetable and seed crops may provide the raw materials for our synthetics industries. In that case, coal will lie in the ground unused. One thing is certain: things will not remain as they are now.

Resource

Bloom, A. L. Geomorphology, An Analysis of Land Forms. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1978.

Stone, D. B. Earth Science. N.p.: American Book Company, 1980.

MEASURING HEAT ENERGY

USE WITH:
Earth Science
Physical Science
General Science

TIME:
1 class period

MATERIALS:
Metal punch
Tin snips
Test tube and holder
Cork
Needle
Coffee can (1 lb.)
Sample of peat
Sample of coal
Wooden kitchen matches

Objectives

The student will:

1. Perform simple calculations to develop energy-related concepts expressed by the terms: fuel, calories, heat transfer, calorimeter.
2. Develop experimental techniques in the use of a simple calorimeter.
3. Measure and compare the relative heat content of coal and peat and make further inferences about these two fuels.

Background Information

Coal, like oil and natural gas, is a fossil fuel formed from the remains of vegetation. Half a billion years ago, the Earth was warmer and wetter than it is now. Fern-like trees, huge mosses, and other tropical plants grew profusely on the Earth's swampy surface. They died and fell into the shallow water, building up layer upon layer. Cut off from oxygen by the water, much of the plant material did not decay. As time passed, the undecayed organic matter built up into the spongy substance called peat. Dirt and sand washed down as sediments and gradually buried the peat deeper and deeper. As the pressure compacted the peat, the hydrogen and oxygen were driven off and almost pure carbon was left behind. This is the hard, shiny, black mineral called coal.

In this activity, your students will use a homemade calorimeter to measure and compare the heat contents of peat and coal.

Procedure

1. Set up the coffee can calorimeter as shown in the diagram.

2. Add 60 ml of tap water to the test tube. Measure the water temperature (°C) and record in Table 1.

3. Measure about 0.2 or 0.3 gram of peat (additional peat will boil the water and confound the results).

4. Place the peat firmly on the needle which is secured in the cork stand.

5. Using a match to ignite the sample of peat, immediately place it beneath the test tube. (Safety first: Do not allow the test tube mouth to point at your face or toward another person.)

6. Watch the sample until it burns completely. When the flame goes out, take the temperature of the water in the test tube and record the reading.

7. Perform the calculations. Calculate the range in water temperature of the water in the test tube and then calculate the calories gained. One calorie is defined as the heat required to raise the temperature of one ml of liquid water one Celsius degree. (Since you used 60 ml of water, you will multiply the difference by 60. This formula may help you:

   $(°C_2 - °C_1) \times 60 = \text{Calories}$

8. Repeat this procedure with the coal sample, and record findings in Table 2.

9. Have the students compare their results with classmates' results to determine which material transferred the most calories to the water.

Discussion

1. Which was the most concentrated of the two fuels?

   The coal.

2. Which seemed to be the cleanest?

   Depends on the purity of the coal; note the amount of dark smoke released by each on burning.

3. Why did you need to use a match to start the reaction? Does it always take energy to get energy?

   This type of reaction (oxidation) requires three factors: fuel, oxygen, and heat. (In living cells, a catalyst can lower the amount of heat required to initiate the reaction.) The coal samples are the fuel; the atmosphere contains the oxygen, and the match provides the heat. These fuels are self-supporting; i.e., they produce enough heat to maintain the combustion.

4. Based upon this experiment, define fuel.

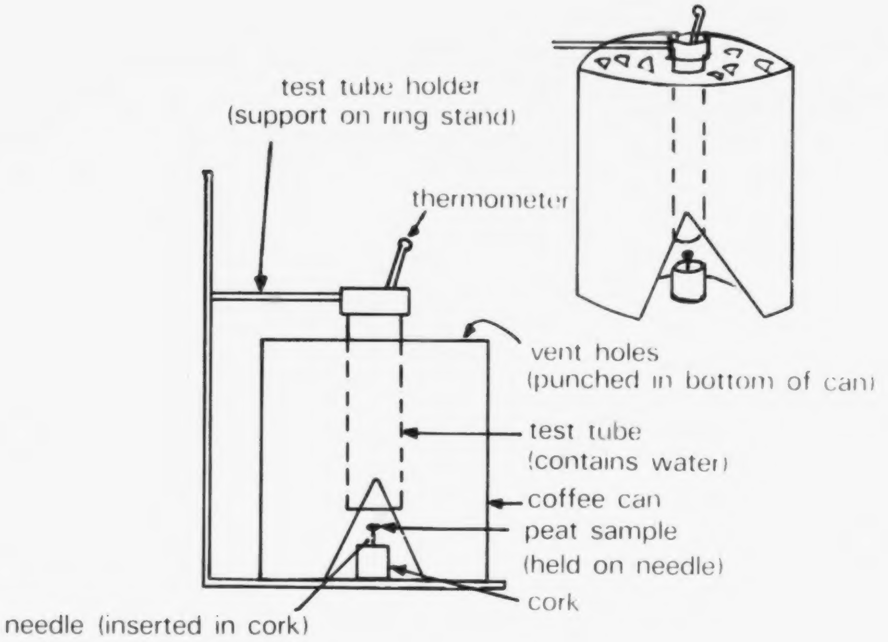
   A chemical substance that reacts with oxygen and releases heat as a byproduct of the reaction is called fuel.

5. Extension

Coal is the most abundant fossil fuel in the Tennessee Valley and comprises more than three-fourths of the known recoverable energy reserves in the U.S. Further, the U.S. has more than half of the free world's coal resources. Considering the properties of coal and peat that you observed in the experiment and these data about coal's abundance, develop a one-page plan of the role of coal in the Tennessee Valley's future. Locate on a regional map all of the TVA power plants. How many are coal-fired? Where should new plants be built and why?

Resource

Tracey, G., H. Trapp and A. Friedl, Modern Physical Science. New York: Holt, Rinehart, and Winston, 1983.


test tube holder
(support on ring stand)
thermometer
vent holes
(punched in bottom of can)
test tube
(contains water)
coffee can
peat sample
(held on needle)
cork
needle (inserted in cork)

Coffee Can Calorimeter

DATA TABLE 1 (PEAT)

	TEMPERATURE
Tap Water	____________C°
Heated Water	____________C°
Difference	____________C°
Calories Gained	____________C°

DATA TABLE 2 (COAL)

	TEMPERATURE
Tap Water	____________C°
Heated Water	____________C°
Difference	____________C°
Calories Gained	____________C°

COAL AND WATER

USE WITH:
Earth Science
General Science
Physical Science

TIME:
1-2 class periods

MATERIALS:
Bituminous coal
oven
Balance (or scales)
Worksheet (included)

Objectives

The student will:

1. Weigh and then dry several samples of high-moisture and low-moisture coal.
2. Calculate the % weight of moisture in high-moisture coal and in low-moisture coal.
3. Compare the energy value (energy per unit of weight) of high-moisture and low-moisture coal.

Background Information

Most of the coal we use today was formed during the Carboniferous period from the remains of plants during that time. All living organisms are composed of hydrogen, carbon, oxygen, and nitrogen. If decay occurs where there is no oxygen, hydrocarbons are left. These hydrocarbons will burn when oxygen is present. Products of burning this hydrocarbon include heat, carbon dioxide gas, and water.

Peat, the first step in coal formation, burns, although there is some moisture present. (Peat is an important fuel in Ireland and Russia.) Lignite has lost most of its moisture, oxygen, and nitrogen. Lignite is used in homes and industry. Bituminous coal is the most efficient heating material but produces more smoke, ash, and sulfur during burning. Peat, lignite, and bituminous coal are sedimentary rocks, but anthracite is a metamorphic rock. Anthracite is the cleanest coal of all because it burns cleaner and longer, but it does not produce as much heat per unit of weight nor is it very abundant in the U.S.

Because bituminous coal is found in such large reserves and also produces more heat than anthracite, it is the primary coal used in the Tennessee Valley.

Some of the impurities from burning coal can now be recycled. For example, ash can be used for making cement or for building roads. Other impurities are now being controlled through new technological developments which allow fewer impurities into the air.

Procedure

As coal was formed, the moisture content decreased as the material went through the stages of formation, changing from peat to lignite to bituminous coal. The moisture content in coal is an economic concern to purchasing companies. This is because the moisture (water) must be paid for and transported with the coal. Also, moisture replaces the elements which contribute heat in coal and lowers the usefulness of the coal as a fuel.

The students will take several coal samples and calculate their moisture content before and after drying (NOTE: To get a better comparison, sample 2 might be soaked in water for a day before the experiment.)

1. Have the students weigh each piece of coal and record its weight.

2. Dry the samples in a low heat oven, turning frequently. (Solar energy could also be used on a sunny day.) Three to six hours may be required to drive off all of the water.

3. Weigh the dry samples and record their weight.

4. Divide the dry weight by the wet weight and then multiply by 100 to determine the % weight of coal (water removed) in each sample. (S1 means sample 1.)

   [S1 g.(dry weight) / S1 g.(wet weight)] x 100 = % coal in S1

5. Covert the weights of the high- and low-moisture coal samples to comparable amounts in tons with this equation.

   % coal in sample x 2000 lbs = lbs. of coal per ton

   Example:

   S1 is the high-moisture coal, assume it was 94% coal (and so 6% water).

   S2 is the low-moisture coal, assume it was 82% coal (and 18% water).

   S1: 94% x 2000 lbs = 1880 lbs coal (and 20 lbs water)
   S2: 82% x 2000 lbs = 1640 lbs coal (and 360 lbs water)

   In transporting sample 2, you are paying a lot to transport the useless water. Also, burning a ton of sample 2 will produce a lot less heat than burning a ton of sample 1, so low-moisture coal is better.

6. Use the following example as a guide to determine how to calculate the energy value of your two coal samples. (1 ton of bituminous coal produces about 24,040,000 Btu and 3414 Btu = 1 kWh.)

   from above: S1: 94% x 24,040,000 Btu = 22,597,600 Btu per ton
   S2: 82% x 24,040,000 Btu = 19,712,800 Btu per ton

7. Convert these to kilowatthours.

   S1: 22,597,600 / 3414 kWh = 6619 kWh per ton
   S2: 19,712,800 / 3414 kWh = 5774 kWh per ton

Discussion

1. Consider the above information and then brainstorm with the entire class a list of factors involved in using coal. (Information from other activities could be useful, such as location of coal deposits in the Valley, location of power plants, transportation networks, and so on.)

   Some of the factors are: type of mine, depth of the coal seam, purity of the coal, type of coal, moisture content of the coal, distance from the mine to user, type of transport available, processing necessary, and use of the coal. What about waste, pollution control, cost of coal, etc.?

2. Discuss the pros and cons of using coal. What are our other choices?

   Check the list above and consider each. What are the pros or cons of each? Discuss.

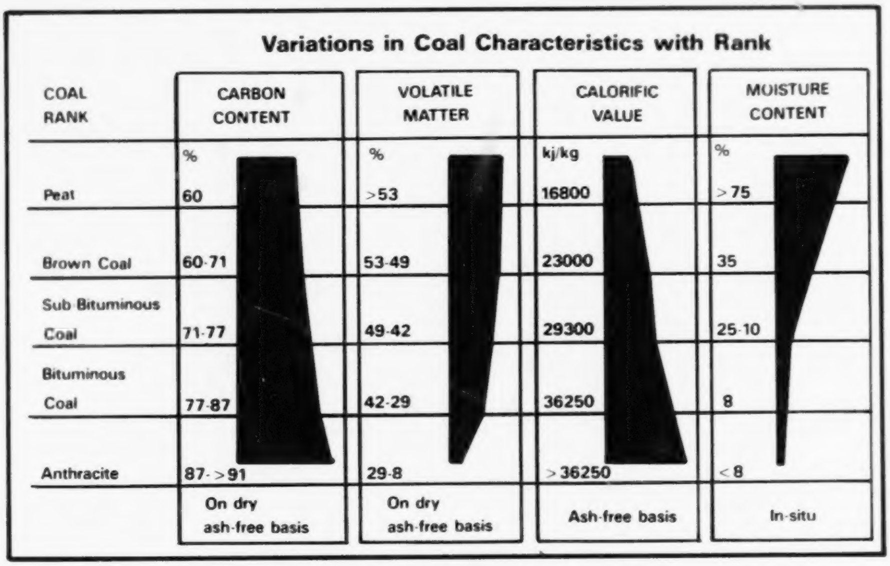
3. Compare the economics of coal to hydro, nuclear, and solar power.

   Construction costs, generation costs per kilowatt, expected fuel availability, life expectancy of each type of plant, expected environmental costs, shut-down costs, and other factors all contribute to the overall economics of energy production. (You may wish to research, or have students research, some specific items.)

MOISTURE DATA SHEET

Directions: Weigh each wet sample and record. Then spread a thin layer on a heat resistant dish (or aluminum pan) and dry in an oven at 350°F. Weigh dry samples and record. Subtract each dry weight from each moist weight.

# SAMPLES WET	# SAMPLES DRY	# DIFFERENCE
1. ________	1. ________	1. ________
2. ________	2. ________	2. ________
3. ________	3. ________	3. ________
4. ________	4. ________	4. ________
5. ________	5. ________	5. ________
6. ________	6. ________	6. ________
7. ________	7. ________	7. ________
8. ________	8. ________	8. ________
9. ________	9. ________	9. ________
10. ________	10. ________	10. ________



Variations in Coal Characteristics with Rank

COAL RANK	CARBON CONTENT	VOLATILE MATTER	CALORIFIC VALUE	MOISTURE CONTENT
	%	%	kj/kg	%
Peat	60	>53	16800	>75
Brown Coal	60-71	53-49	23000	35
Sub Bituminous Coal	71-77	49-42	29300	25-10
Bituminous Coal	77-87	42-29	36250	8
Anthracite	87->91	29-8	>36250	<8
	On dry ash-free basis	On dry ash-free basis	Ash-free basis	In-situ

As coal progresses in rank, carbon content and calorific (or energy) value increase, while the percentages of volatile matter and moisture content present decrease.

ACID RAIN

Objectives

The students will:
1. Demonstrate the reaction of acid precipitation on limestone and granite materials.
2. Analyze the possible effects in our natural environment.

USE WITH:
Ecology/Environmental Science
Earth Science
General Science
Physical Science

TIME:
1 class period

MATERIALS:
2-liter container of crushed limestone (available at garden supply)
2-liter container of crushed granite (available at garden supply)
Three 1-gallon plastic bottles
Two clear pint-size collecting containers
Sulfuric acid
pH indicator solution

Background Information

Although normal rainfall is slightly acidic by nature (pH 5.6), acidic precipitation contains a significant amount of sulfuric and nitric acid. The sources for this activity are both natural and man-made. Acid rain is produced naturally through geothermal emissions and biological processes. However, man-made sources are the most significant contributors by far. They include the emissions from automobiles and other types of vehicles and also the burning of fossil fuels by public utilities and industries.

These processes release various particles and sulfuric and nitric oxides into the atmosphere. These are then carried through the atmosphere by wind currents and are oxidized, mixing with water vapor and producing sulfuric and nitric acids. These acids reach the ground in rain and snow, finding their way into the groundwater system. Sometimes the particles of oxidized material fall directly to the ground in dry form and are combined with surface waters to produce acids.

Even though much of our country has a significant amount of acid precipitation, certain areas seem to suffer a greater impact than others. One reason for this is the geology of the particular region. In areas where the bedrock is limestone, the acid precipitation can be somewhat neutralized through acid-base reactions, thereby lessening its impact. In areas such as the Adirondack Mountains of New York, the bedrock is generally granite, which does not neutralize acid. There, and in other similar areas, the acid rain enters the groundwater systems virtually undiluted, causing the acidity of these systems to increase and affecting the delicate plant and animal communities in those areas.

Procedure

1. Cut off the bottoms from two clean 1-gallon plastic milk containers (the large size of clear plastic soda bottle may also be used).
2. Turn them upside down and support them so that they are stable. (These will be filled with heavy rocks so a strong support is needed.) Place 1-pint collecting containers beneath the spouts. Place crushed granite in one container and crushed limestone in the other.
3. Draw tap water and determine its pH.
4. Mix tap water with sulfuric acid solution in the remaining gallon bottle to achieve a 4.2 pH. This will approximate the acidity of rainfall in the Tennessee Valley.
5. Place pH indicator solution in both collecting containers.
6. Slowly pour one-half of the "acid rain" solution into each container of crushed rock.
7. Observe.
8. Using a water test kit (or other means of determining pH), determine the acidity of the liquid in each collecting container.
9. Use a table like the following to record your data:

	GRANITE	LIMESTONE
pH of "acid rain"	________	________
pH of water after passing through the rock	________	________

Discussion

1. Was there a color change in the containers? If so, explain this observation.

   The non-neutralized and the neutralized "acid rain" solutions were different colors, indicating different acidities resulting from contact with the rocks. (See the chart provided with the pH indicator solution to determine approximate pH of each solution.)

2. Is there a significant pH change in either container? If so, why do you think that this has occurred?

   The pH values obtained from the indicator chart show that there is a difference. Remember also that pH values are log values, not linear, and a change from 5 to 6 means a power of ten difference. A change from 5 to 7 means a power of 100 difference. The limestone neutralized the acid, but the granite did not.

3. How could acidic pH levels in precipitation affect the water quality of a region?

   Even a slight change in the pH of an aquatic habitat can have a significant effect on the small organisms which form the basis of aquatic food chains. In this way, the wildlife can be greatly affected. Additionally, a pH change can change the normal concentrations of nutrients and other chemicals in the water. This too can have significant impacts on wildlife.

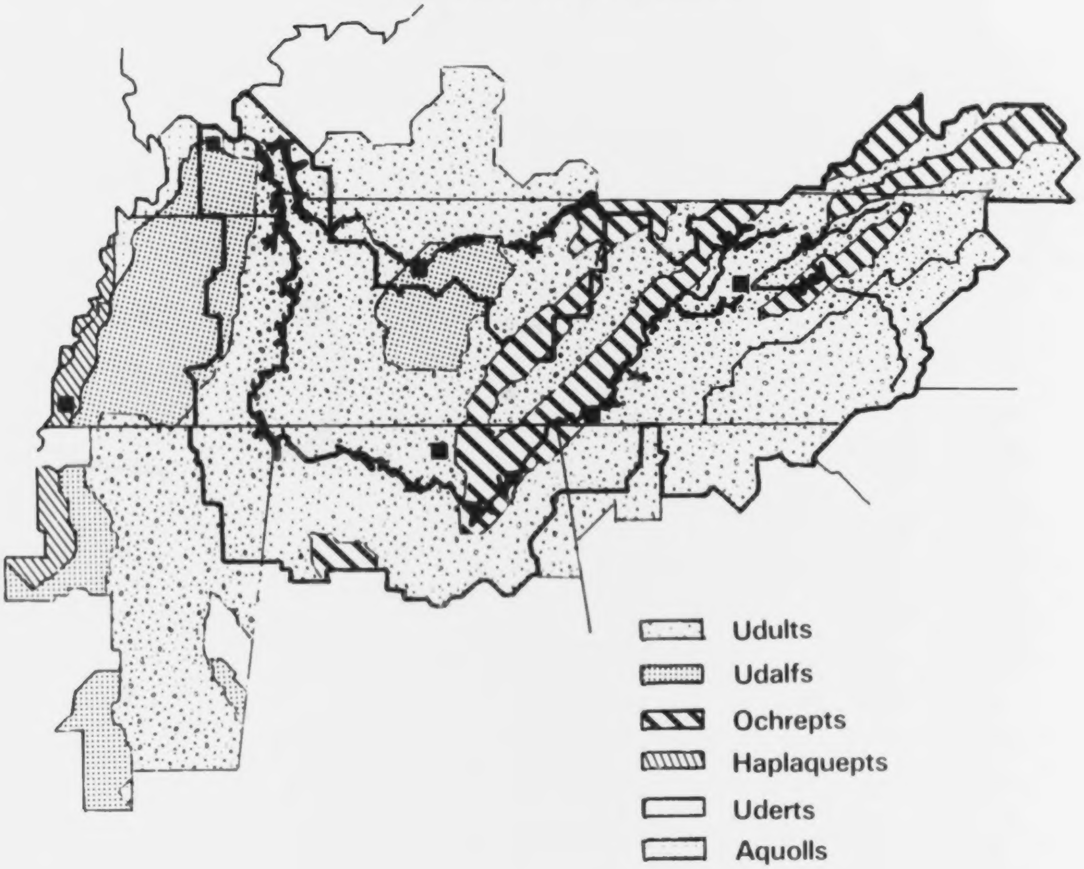
4. Extension

   a. What are the major sources of acid precipitation? How is it transmitted? Contact the National Oceanographic and Atmospheric Administration (NOAA) for information on acid precipitation monitoring that is taking place in the U.S. and in Canada. Considering this information, what is the best approach for reducing or eliminating acid rain?

   b. Collect some local rock samples for use in the above activity. Is your local base rock an acid neutralizer? Check the map provided. Regions with limestone rock have a natural ability to neutralize acid rain or other acidity and so are not as affected. On the other hand, regions with mostly granite rocks will be sensitive to any increase in the normal acidity of the environment.

   c. From the soil type, predict the effects of acid rain on the local water systems in the Valley regions. Which area(s) is (are) most susceptible? (See Soils of the Valley.)

SOILS OF THE VALLEY *


Udults
Udalfs
Ochrepts
Haplaquepts
Uderts
Aquolls

Soils of the Tennessee Valley are usually moist, but they may become dry during the summer. The predominant soil type is an Udult, which is also the predominant soil type throughout the South. There are smaller proportions of Udalfs, Ochrepts, and Haplaquepts and isolated areas of Uderts and Aquolls.

Tennessee Valley Authority. The First Fifty Years: Changed Land, Changed Lives. N.p.: TVA, 1983.

Udults (Order Ultisols) are moist, low-alkaline soils that have relatively low levels of organic matter below the surface. They are dry for very short periods, if at all. Udults are good soils for general farming, woodland, pasture, cotton, and tobacco.

Udalfs (Order Alfisols) are found in temperate and tropical regions. Although usually moist, Udalfs may become dry for short periods during the summer. Udalfs, found primarily in middle and west Tennessee, are good soils for row crops, small grains, and pasture.

Ochrepts (Order Inceptisols) are soils that were formed from crystalline clay minerals. These light-colored soils, found in eastern Tennessee, northern Alabama, and the southwest corner of Virginia, support woodland, pasture, wheat, sorghum, hay, silage, and corn.

Haplaquepts (Order Incepticols) are seasonally wet soils that have high levels of organic matter and sodium. Because these soils occur in association with the Mississippi River, they are found only along the extreme western border of the region. The Haplaquepts are used for pasture, hay, woodland, pasture, and where drained, hardy vegetables.

Uderts (Order Vertisols) are usually moist soils. They have wide, deep cracks that often open and close several times a year; however, these cracks do not stay open continuously for more than 2 months. Uderts are good soils for cotton, corn, small grain, pasture, and rice.

Aquolls (Order Mollisols) are seasonally wet soils that have a thick black surface horizon and gray subsurface horizons. Aquolls are used for pasture and, where drained, for small grains, corn, and potatoes.

RECLAIMING LAND

USE WITH:
Ecology/Environmental Science
Earth Science
General Science

TIME:
1-4 class periods depending upon the the weather

MATERIALS:
Shovels and picks
Camera, film

Objectives

The student will:

1. Research current surface mining practices.
2. Simulate surface mining and reclamation to original contour.
3. Monitor soil erosion that results from this activity.
4. Keep a chronological photographic journal of this simulation to document their "compliance record."

Background Information

Of the 117,000 acres of coal lands surface mined prior to comprehensive reclamation requirements, some 54,742 acres remain either inadequately or totally unreclaimed in the Tennessee Valley. In 1977 the Federal Surface Mining Control and Reclamation Act (SMCRA) was enacted. The law establishes financing and a priority system to reclaim orphan mines and mitigate their associated hazards. Funds are coming from a special fee on coal production and from other sources. Top priority is placed on (1) land and water affected by the orphan mine and (2) those mines where there is no continuing reclamation responsibility by state or other federal laws.

Erosion on raw, unvegetated mine-spoils is the most serious environmental problem of abandoned mine lands. Annual sediment load from these lands may average 2,400 tons per square mile per year (about 100 times the amount of sediment from a similar unmined forest watershed). Silt or sediment alters the chemical balance of water, buries aquatic organisms, alters feeding and spawning habits, and suffocates fish by coating their gills. Sediment clogs streams, rivers, and reservoirs, resulting in reduced flow capacity of streams and the water-holding capacity of reservoirs, increasing the possibility of flood damage. In addition, sediment damages hydroelectric units, reduces the recreational value of streams and reservoirs, and hampers water supply operation by increasing treatment costs, causing excessive wear on equipment through abrasion and the clogging or covering-over of intake pipes.

In addition to silt problems, some Valley coalbeds have acid-forming (pyritic) material in the overburden strata. At many coal mine sites, this material is near the surface. Once exposed to air and water, it produces acid drainage that degrades the water and soil quality of the watershed, hampers revegetation, and destroys sensitive habitats and species.

The Tennessee Valley Authority (TVA) established demonstrations in the Valley during the 1960s and 1970s to illustrate how abandoned coal lands could be reclaimed. In 1963 there were four projects in two states under the Accelerated Public Works Program. From 1976 to 1980, in cooperation with state agencies and local soil and water conservation districts, TVA reclaimed orphan coal mine lands in 38 Alabama, Kentucky, Tennessee, and Virginia counties.

Before TVA issues a contract to a potential coal supplier, the agency checks the coal supplier's previous compliance record. All contractors must be in compliance with state and federal laws on reclamation. Once a contract is issued, TVA follows through with monitoring and check points to ensure that contractors meet their responsibilities.

To mine new deposits today, a coal company must first apply for a permit, post a bond to cover reclamation, and then return land to its approximate original contour after mining is done. Both state and federal governments monitor the reclamation to ensure compliance with the law.

Procedure

Soil erosion is a major environmental problem caused by strip mining coal. In the past, these mines were often abandoned or not managed properly. They were referred to as "orphan mines." This activity will simulate contour mining, one of the two methods of strip mining.

1. Have the students research strip mining to gain an overview of this process.

2. Locate a small hillside with little or no erosion problems. Set up and photograph the contour of the selected area.

3. Ask the students to make 3-foot cuts along the contour, one cut above the other. The students should be going deeper into the hillside as they make each cut.

4. Remove the soil (this is called mine spoils) from the mining area. Use the spoils to form a ridge 2 feet below the last cut; this is referred to as the spoils bank.

5. Monitor the hillside daily for about one week, or until it has rained at least once. Check for erosion, falling rocks, etc. Continue to take photographs.

6. After a period of time, reclaim the land. From the spoils ridge, take the soil and fill in the cut, then plant new vegetation.

7. Continue to monitor the "mined" area. Check to see that no further problems occur.

8. Organize your slides into a slide series to document the entire activity. Also develop a report which records your observations. Be sure to include the hillside before the cuts, the erosion due to the activity, the erosion after the activity, and the reclamation process.

Discussion

1. When was erosion the greatest? Compare the erosion before, during, and after.

   Depends upon soil type, but probably erosion is greatest during initial digging stages. Greater amounts of rainfall (usually depends on the season) will increase erosion, of course.

2. The erosion caused by not reclaiming mine lands leads to groundwater pollution, loss of fertile soil, potential flood damage, siltation of reservoirs and streams, and other problems. Brainstorm with the class to create a list of any and all problems that you feel occurred as a result of this activity. Mining is on a much larger scale and so the effects will be greater due to scale. After completing the list, establish priorities on the list from very significant to minor and then develop suggestions on how to reduce or remove the most significant problems. (Reclaimed land is used for farming, waterfowl nesting areas and sanctuaries, vineyards, and other uses. In many cases the land is even more useful and productive than it was before mining.)

Resource

Haynes, N. Biological Sciences: An Ecological Approach. New York: Houghton Mifflin Company, 1982.

MAKING DECISIONS

Objectives

The student will:

1. Research prevalent roles/outlooks of persons in their communities on resource/environmental issues.
2. Develop a planimetric map of a community similar to their own.
3. Demonstrate group process roles in developing and presenting this simulation.

USE WITH:
Civics
Earth Science
Economics
General Science
Social Studies

TIME:
1-3 class periods

MATERIALS:
Colored markers
Newsprint
Masking tape
Example of a planimetric map
Worksheets (included)

Background Information

Coal produces over 55 percent of the electricity generated in the United States. Traditionally, the energy produced from burning coal is used to heat water to produce steam which drives turbine generators. These generators produce electricity for commerce, for maintenance of our standard of living, and for national security. Recovering the coal necessary to produce electricity can have a direct effect on our economy and also on our environmental quality.

Procedure

This activity uses a simulation to involve students in making decisions relative to recovering and processing coal on land surrounding the community of Cedar Ridge.

Scenario: The community of Cedar Ridge is economically dependent on farming, tourism, and several small lumber mills. Its source of water is Wolf River. Little money is available for improving or expanding services for the community. Generally, Cedar Ridge is a quiet, somewhat stable town which is reluctant to change. The prevailing attitude is "By gosh! If it was good enough for my grandfather, it's good enough for me!" However, during the past ten years, the tourism industry has drawn many new citizens who are young, educated, and generally more accepting of change than the older citizens in the community.

Coal was recently discovered in the foothills near Cedar Ridge. Much of this area includes prime farm land and several forested sections, which border on a state park used by citizens of the community and by tourists. A large utility company plans to develop this energy source. A local committee of citizens has been selected to determine if this would be in the best interest of Cedar Ridge and the surrounding area.

1. To provide a visual model of the community and to initiate the activity, the teacher should have the class develop a planimetric map of the area.

   The map should be at least 2 feet square, using a scale of one foot equals one mile. Include 40 percent wooded area, 40 percent farm land, and 20 percent foothills and mountains. Locate the community of Cedar Ridge in the foothills adjacent to the Wolf River.

2. Next, students need to identify whom they believe should serve on the committee. For example:

   1. Utility company board member
   2. Local conservation group representative
   3. Newspaper editor
   4. State senator
   5. Member of the Chamber of Commerce
   6. Banker
   7. Manager of a lumber mill
   8. Farmer who owns the coal fields
   9. General public

3. Students should select roles they wish to assume and then research the roles. Individuals in the community that may have insight into these roles should be interviewed. Select a committee person to be the chairperson.

4. After researching his/her role, each committee member should prepare a position statement (supporting or not supporting the resource development project). Alternate positions may also be presented as this may not be a black and white issue.

5. The committee's research staff should be asked to provide information on various issues such as economic impact on the community, water requirements for coal processing, trade-offs involved in converting wooded lands and farm lands to strip mines, the value of reclaimed land (and uses), effects on wildlife, problems involved when the surface rights to the land are held by someone other than the owner of the mineral rights, etc.

   The city council should research legal implications of possible decisions it anticipates the committee will recommend.

6. The simulation culminates when the committee and its staff report to the city council with recommendations and plans for resource development of Cedar Ridge.

Discussion

Debriefing the simulation is the most important instructional part of this activity.

1. What implications does the final decision have on the future of the community?

   This is a long-term decision, and the effects of extracting coal may be around for a long time if it is done improperly. Allow time for students to think and summarize the results. Accept any answer that can be supported.

2. What are the "trade-offs" involved in this situation?

   Include jobs, capital, environment, others.

3. If you lived in Cedar Ridge, which option would you choose? Why?

4. What areas of coal production and consumption are regulated? How do these regulations protect employees and maintain environmental quality?

   Nearly all areas. Ask someone with local expertise to come and address the issue as a subject-matter expert before and during the community hearing simulation.

5. Extension

   a. Attend an actual committee hearing to see how these issues are handled. Why are hearings important in a democracy?

   b. Videotape the mock hearing in this activity and edit it for future students to use. Add narration, sound effects, and an introduction/overview and summary.

   c. Research the 1970 and 1977 Clean Air Acts, or the Surface Mining Control and Reclamation Act of 1977, or the Mine Health and Safety Act of 1977. Organize the information and present it to the class.

Role Descriptions

Utility Company Board Member

You are very much in favor of utilizing this coal. You feel that the environmental problems can be minimized and controlled. The coal extraction will benefit the area in two ways. It will directly provide some jobs for local area residents, and indirectly it will save the power company money, which could ultimately lower electric rates for all area consumers, spurring continued economic growth. For the power company, the lower cost of this local coal will help the company remain solvent. Heavy outlays of capital for large, expensive plants put a large debt burden on the company, and every little bit helps. You need to help your company survive and make a profit. In doing so, you will help the entire area.

Conservation Group Member

You are strongly opposed to using this coal deposit You are convinced that the environmental damage cannot be reduced adequately. You believe that the coal extraction process will acidify and silt up the river, making it unattractive to wildlife. This polluted water will reduce outdoor recreation opportunities and could also affect the drinking water quality of the area residents of Cedar Ridge. Farm production also could be adversely affected on those farms that depend upon this water for crop irrigation due to both the acidity of the water and the harm done to the farmers' pumps, pipe lines, sprinklers, etc.

Newspaper Editor

You have no strong convictions either way, but you are leaning toward coal removal. Local businesses (including tourism and lumber businesses) provide most of the newspaper revenue through advertising, so anything that is good for local business is good for the newspaper. Also, environmental issues (except disasters) don't sell newspapers. The public is generally blasé about the environment, and these kinds of articles end up on page 14 after the obituaries. New jobs, on the other hand, are page 1 news!

State Senator

Business keeps the state and federal coffers full, but voters decide who goes to the senate next year. Your job is to support business while also supporting issues that most people support. Remember that a negative environmental stance is a strong but not fatal blow to a politician. It is all right to support the extraction of the coal and at the same time maintain that there will be no adverse environmental problems from the extraction.

Chamber of Commerce Member

As a representative of the area businesses, you support coal extraction but you also want some information about how the process will affect the local economy and the local environment. You want the power company and the coal company to do an economic and environmental study that is more complete than required by state and federal laws. You also want a written agreement, backed up by a trust fund or bond, to guarantee damage settlements for any unexpected problems and a complete plan for recovery of the coal land areas after extraction.

Banker

You are opposed to the extraction of the coal. You believe that any gains for the area would be short term, and you have the long term in view. Most of your loans are to farmers, and to tourism businesses. These have been the foundation of the economy in Cedar Ridge for decades and will probably remain so for an indefinite time to come. If the coal extraction hurts the farmers or the tourism businesses, these loans may go into default, and this would hurt the bank. It is not worth the risk.

Lumber Mill Manager

You are opposed to the coal mine. The lumber mill requires seasonal labor, and some of this skilled labor would be attracted to the mine where the work is year-round. The mine might even raise the local minimum wage. The lumber mill (which is heavily labor-intensive) cannot afford to pay higher salaries.

Farmer, Owner of the Coal Fields

You are in favor of developing the coal bed. After all, it does belong to you, and in America, you have freedom, and you can do whatever you want with your land. Also, it would be nice to be able to retire and pay off all of your bank debts from farming.

General Public

You may favor or oppose the coal extraction. Decide your occupation or vocation and follow your principles. Research to find out information to support your viewpoint.

GLOSSARY

Acid rain (acid precipitation):	rain or snow with a pH of less than 5.6.
Biochemical decomposition:	the more or less permanent structural breakdown of a molecule into simpler molecules or atoms. (See chemical weathering.)
Carboniferous:	a division of late Paleozoic rocks (and geologic time between the Devonian and Permian) including the Mississippian and Pennsylvanian periods.
Chemical weathering:	a weathering process by which rocks and minerals are transformed into new, fairly stable chemical combinations by such chemical reactions as hydrolysis, oxidation, ion exchange, and solution.
Coal reserve:	valuable known deposits that are presently economically recoverable and may be so in the future.
Coke:	carbonized coal residue remaining from the dry (destructive) distillation of a coking coal or other carbonaceous material.
Compliance record:	verifiable records of the reclamation steps taken in accordance with legal requirements by coal mine operators (or others).
Extrapolate:	to estimate (best guess) or infer an unknown value, quantity, or other data based upon known data which the estimated value is assumed to follow.
Geologic time:	the period of time covered by historical geology, from the end of the formation of the Earth as a separate planet to the beginning of written history.
Geological processes:	physical and chemical processes that occur in the earth and its environment, that is, earth, air, and (by extension) space. (See biochemical decomposition.)

Interpolate:	a process used to determine an intermediate value when several discrete values are known.
Mine spoils:	the overburden or non-ore material from a coal mine.
Organic rock:	a sedimentary rock composed principally of the remains of plants and animals.
Original contour:	the shape and slope of the land surface before the mining operations begin.
Orphan mines:	a common name usually given to coal mines that have been abandoned after the easily obtainable coal has been removed and little or no reclamation has been carried out. Normally, legal responsibility for reclamation cannot be determined.
Overburden strata:	material of any nature, consolidated or unconsolidated, that overlies a deposit of useful materials, ores, or coal, especially those deposits that are mined from the surface by open cuts.
pH:	a term used to describe the hydrogenion activity of a system; a solution of pH 0 to 7 is acid, pH of 7 is neutral, and pH over 7 to 14 is alkaline.
Planimetric map:	an orthographic drawing on a horizontal plane; a large-scale map or chart of a small area, often of a town or community.
Public utility:	a business organization considered by law to be vested with public interest and subject to public regulation.
Pyritic material:	material containing FeS_2, iron pyrite (also called fool's gold).
Reclamation:	the recovery of land or other natural resource that has been disturbed because of fire, water, or other cause.
Sediment load:	the solid material that is transported by a natural agent, especially by a stream.
Siltation:	the filling up or raising of the bed of a body of water by depositing silt.

Transportation networks:	interconnected systems for transport, including rail systems, road systems, and water systems.

REFERENCES

American Petroleum Industry. *Movies and Energy*. (An annotated list of films.) Washington, D. C.: API, n.d.

Arms, K. and P. S. Camp. *Biology*, 2nd ed. N.p.: Saunders College Publishing, 1982.

An American Asset. (28-minute film.) New Hyde Park, New York: Modern Talking Picture Services, Inc., n.d.

Australian Coal Association. *Coal and Australia*. Sydney: ACA, 1982. (Mailing address: Australian Coal Association, GPO Box 2668, Sydney, Australia 2001.)

Bloom, A. L. *Geomorphology, An Analysis of Land Forms*. Englewood Cliffs, NJ: Prentice Hall, Inc., 1978.

Brown, T. and H. E. LeMay. *The Central Science: Chemistry*. Englewood Cliffs, NJ: Prentice-Hall, 1981.

Burchfield, C. B. *Physical Geology*. N.p.: Bell and Howell Company, 1982.

Dorin, H. *The Study of Matter: Chemistry*. N.p.: Cebco Standard Publishing, 1982.

Fischer, A. G. *Invertebrate Fossils*. New York: McGraw-Hill, 1952.

Friedman, G. *Principles of Sedimentology*. New York: Wiley Company, 1978.

Haynes N. *Biological Sciences: An Ecological Approach*. New York: Houghton Mifflin Company, 1982.

Kenneth, J. P. *Marine Geology*. Englewood Cliffs, NJ: Prentice-Hall, 1982.

Kirchen, W. *Our Natural Resources*. N.p.: Interstate Printers and Publishers, 1982.

Mathews, W. H. *Investigating the Earth*. New York: Houghton Mifflin Company, 1982.

National Coal Association. *Coal*; reprinted from the World Book Encyclopedia. N.p.: n.p., n.d.

Stapp, W. B. and D. A. Cox. *Environmental Education Activities Manual*, Vol VI, 2nd ed. Farmington Hills, MI: N.p., 1975.

Stone, D. B. Earth Science. N.p.: American Book Company, 1980.

Stout, B. A. Energy Use and Management in Agriculture. N.p.: Breton Publishers, 1984.

Tennessee Valley Authority. The First Fifty Years: Changed Land, Changed Lives. N.p.: TVA, 1983.

Tracey, G., H. Trapp and A. Friedl. Modern Physical Science. New York: Holt, Rinehart, and Winston, 1983.

U. S. Department of Energy. Classroom Science Films. (Catalog of free films.) Oak Ridge, TN: USDOE, Technical Information Center, n.d.

NUCLEAR ENERGY

OVERVIEW

Throughout history few single events have materially altered the course of civilization, but one was the completion and successful operation of the first nuclear reactor. That event, which took place on December 2, 1942, has been compared to the manufacture of the first automobile in its impact on the future and its significance for social change.

Since 1942, vast amounts of research have gone into the development of nuclear energy, providing the potential for an enormous amount of electricity. The mid-seventies saw the Tennessee Valley taking the lead in plans to build and use nuclear power plants as a major source of electricity. However, the rapid rise in the costs of energy and construction, a decrease in the use of energy, and numerous technical problems have caused the cancellation of nuclear plants in the planning and construction stages. TVA currently is producing no electricity from nuclear power as there are no TVA nuclear plants on-line at this time.

The fuel needed for a conventional nuclear reactor is uranium. As a finite mineral, uranium labels nuclear energy as it is used today as a nonrenewable source of energy. Deposits of uranium ore are located in the western United States, with known reserves of 980,000 tons. On the average, one ton of ore will produce four pounds of uranium, but of that four pounds only 0.7 percent (about 0.1 ounce) is the fissionable U-235 isotope. The fuel cycle begins with the mining of ore, followed by milling of the usable ore, and the most difficult step, enrichment of the uranium in a process called gaseous diffusion. The enriched uranium is sent to a fabrication plant and pressed into pellets about 3/8-inch in diameter and 1/2-inch long. The pellets are then inserted end to end into twelve 4-foot-long metal tubes called fuel rods. After being bound together in fuel assemblies, the fuel rods are sent to the power plants. About 200 fuel assemblies are needed for each reactor, and one-fourth to one-third are replaced each year.

Heat energy is released from U-235 during the fission reaction. In a Boiling Water Reactor, steam produced from the heat released by the controlled fission is used directly to drive the turbines. In a Pressurized Water Reactor, heat is transferred from a primary loop to a heat exchanger, and the steam generated in the secondary loop is sent to the turbines. The turbines cause rotor coils to rotate as the stator coils remain stationary in the generators, producing alternating current. The electricity produced is sent through transformers and distributed over powerlines to homes, commercial businesses, and industries.

A major cost of nuclear energy is incurred during the construction phase, and since 1976 the cost of building a nuclear power plant has nearly tripled. The reasons behind this escalation of capital cost are varied. First, the length of construction time has increased to 10 years or more as a result of changes in safety and environmental standards. Longer construction time means additional capital costs. In addition, costs of materials, labor, and components and interest rates on borrowed money have increased. In calculating the true cost, capital expenditures, fuel, operation, maintenance, and interest on borrowed money are all considered. In 1985, TVA's generating cost for nuclear energy was 2.447 cents per kilowatthour as compared to 0.254 cents per kilowatthour for hydro-electricity and 2.172 cents per kilowatthour for coal-fired plants. (In 1984, the costs of nuclear-generated electricity were lower than those for coal-produced power.)

Harnessing any energy for use by man-made systems has environmental effects. A major concern regarding nuclear power is radiation, from either the plant or the handling of radioactive wastes. Although nuclear power plants release small amounts of radiation into the atmosphere, the amounts are much less than natural background radiation. Low-level radioactive waste is sealed in steel containers and shipped to licensed disposal sites. The higher level of radioactive waste, primarily spent fuel, is presently stored on-site. Another concern is thermal pollution of the large amounts of water required for cooling a nuclear plant. The release of excessive heat into a river could cause serious damage to aquatic life. Therefore, excessive heat is sent first to cooling ponds or cooling towers to release the heat to the atmosphere through evaporation.

Nuclear power, an important resource in the Tennessee Valley, produced almost 18 billion kilowatthours of electricity in 1985, down from nearly 25 billion in 1984. As is true of every energy resource, there are advantages and disadvantages in the production and use of nuclear power to meet the needs of consumers. These trade-offs must be balanced to make sure that ecological systems are disturbed as little as possible. A continuous research process seeks to place as many safeguards on these man-made systems as are necessary. The man-made environment has an impact on the natural environment, but knowledge and skills are being developed to lessen that impact. An informed and aware citizenry plays one of the most important roles in monitoring this man-made environment.

266

THE INVERSE SQUARE LAW

Objectives

The student will:

1. Observe the distribution of energy over different distances from an energy source.
2. Construct a model representing energy distribution based on experimental data.
3. Make predictions regarding energy intensity using the inverse square law.

USE WITH:
Physics
Physical Science
Earth Sciences
Mathematics

TIME:
1 class period for each of three separate activities.

MATERIALS:
Activity #1:
- Worksheets (included)
- Scissors

Activity #2:
- Can of spray paint
- Ruler
- Paper (4 sheets)

Activity #3:
- Geiger counter
- Radioactive sample
- Ruler
- Graph paper
- Worksheets (included)

Background Information

Most types of energy adhere to the inverse square law as the energy is radiated from a source. For example, gravity, light, and other electromagnetic radiations, magnetism, sound, and electrostatic forces, as well as nuclear radiation, follow the inverse square law.

The inverse square law states that the intensity of energy radiation at some distance from a source will be inversely proportional to the square of the distance from the source. This means that the intensity of the energy decreases as the distance from the source increases. In fact, the intensity will decrease faster than the distance is increasing.

We can say that the intensity is inversely proportional to the square of the distance

where I = intensity of energy and s2 = distance from the source squared.

We can convert the proportion to an equation by substituting a constant of proportionality:

$$I = k/s^2$$

Where K = a constant

Procedure

Each of the three activities can be used alone to illustrate the inverse square law, or all can be used to "work up" to the application of the inverse square law to nuclear radiation.

1. Discuss or review the definition and formula of the inverse square law.

2. Each activity has its own set of student instructions and list of materials. Before beginning the activity give students all required materials. Tell them to read through each set of instructions before beginning the activity.

3. As each activity is completed, follow with discussion.

4. If all three activities are used, the review may be used as an extended discussion or as a quiz.

Discussion: Activity #1

In this example, suppose there is a source of energy at zero. The first square is 1 inch from the source where it is exposed to all the energy between the two diagonal lines. As the distance increases to 2 inches, the energy is spread out over four squares. But the X square receives only one-fourth of the energy. The energy received by the X square is equal to $1/S^2$, where S is the distance from the source.

At a distance of 4 inches from the source the energy is spread out over 16 squares. The X square receives only one-sixteenth of the energy. The same is true at 7 inches where there are 40 squares and the X square receives only one forty-ninth of the energy.

In this activity, it was found that the area of the small square represents $1/S^2$ of the large area, where S distance from the source. Now, assume that the source is a source of radiation, and the small square represents the area of a human body. Remember that the radiation spreads out as it moves away from the source. As it spreads out, less of the radiation strikes the body.

At one unit of distance the body will be exposed to a certain amount of radiation energy. At two distance units the body, represented by the X square, has intercepted only one-fourth the radiation energy since the radiation is spread out (even though the area of the body remains constant). Likewise, at four distance units, the body intercepts only one-sixteenth of the radiation energy. The energy is spread out over an area that is 16 times greater than at one distance unit. At seven distance units, the body is exposed only to one-forty-ninth of the radiation.

What would happen at a distance of 10 units? The area of a human body would only be __________ of the total area and a person would be exposed to only _________ of the radiation energy. At a distance of 100 units from the source exposure would be only ___________ of the total amount of energy.

The inverse square law dictates that exposure to radiation decreases more rapidly than the distance from the source increases . In other words, the farther one is away from a source of radiation, the safer one is.

Discussion: Activity #2

Notice that the product (last row on data table) is a constant (or is nearly a constant). That is because the inverse square law, which says that the intensity of radiated energy is inversely proportional to the square of the distance from the energy source, can be written as:

$I = k/s^2$

where I = intensity of energy, k = a constant, s^2 = distance from the source squared.

The equation can be rearranged to solve for k:

$k = I \times s^2$

which says that k, the constant, is equal to the product of the intensity times the distance squared, just what we have in the bottom of the data table. Since k is a constant, then it does not change (very much) from the data point to the next.

An analogy can be drawn between the point and nuclear radiation. The farther one is from the source of the radiation, the less will be the intensity of the radiation because it is spread out over a greater area.

Discussion: Activity #3

Draw a graph of the relationship between corrected counts to $1/s^2$. Put the corrected counts on the vertical axis and $1/s^2$ on the horizontal axis. Plot each point and draw a straight line so that it is closest to each of the points. (It may not touch any or all of the points.) Determine the slope of the line.

Here it is graphically illustrated that the intensity of nuclear radiation is inversely proportional to the square of the distance between the source and the Geiger tube.

Review

1. Restate the inverse square law in your own words.

   The inverse square law describes the way energy spreads out from a source. It says that the intensity of the energy is inversely proportional to the square of the distance from the source.

2. State the inverse square law with a mathematical formula.

   $I = k/s^2$, where I = intensity, k = constant, s = distance

3. Suppose that a radiation detector indicates an intensity of 100.0 radiation units at a distance of 1.00 meter from a radiation source. What will be the reading at 5.00 meters? At 50.0?

   a. 4.00 radiation units
   b. 0.0400 radiation units

4. Suppose that the radiation detector used above detects a radiation of 0.250 radiation units. How far away from the source is the detector?

   20.0 meters

5. Which is the stronger radiation source, one that produces an intensity of 8.33 units at 3.00 meters or one that produces an energy intensity of 500 units at a distance of 15.0 meters?

   The source that produced the 0.500 units at 15 meters is more intense.

6. Should one be unconcerned about the threat of exposure to radiation because of the inverse square law?

   Most definitely one should be concerned about radiation hazards. However, understanding of the inverse square law provides the knowledge that radiation becomes less of a threat the farther one is away from the source.

INVERSE SQUARE LAW
(Activity #1)

Instructions

1. Orient the paper with the word "top" at the top.

2. Notice the four areas filled in with squares.

3. Cut along the top line, the right side, and the bottom, but not along the left side. When the three sides of each of the four areas have been cut, fold the areas up so that they are perpendicular to the paper. Refer to figure 2.

4. Fill in the data table using information from Figure 1.

Distance	1 in.	2 in.	4 in.	7 in.
Number of squares in each grid	______	______	______	______
Fraction that 1 square is of total squares	1/____	1/____	1/____	1/____

Notice anything interesting? ____

(Hint: Look at the distance in inches and the number of squares in each grid.)

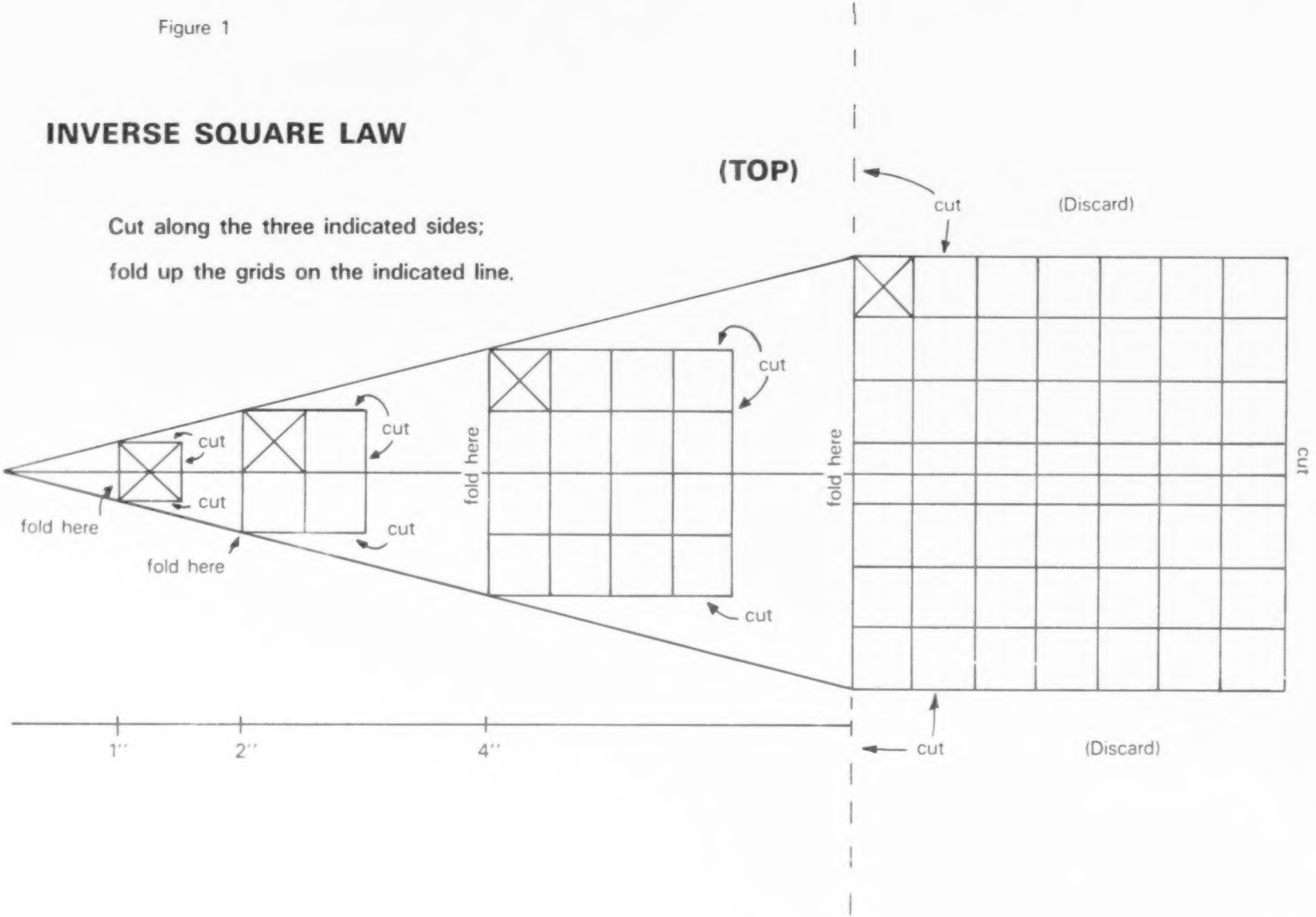
WORKSHEET

Figure 1

INVERSE SQUARE LAW

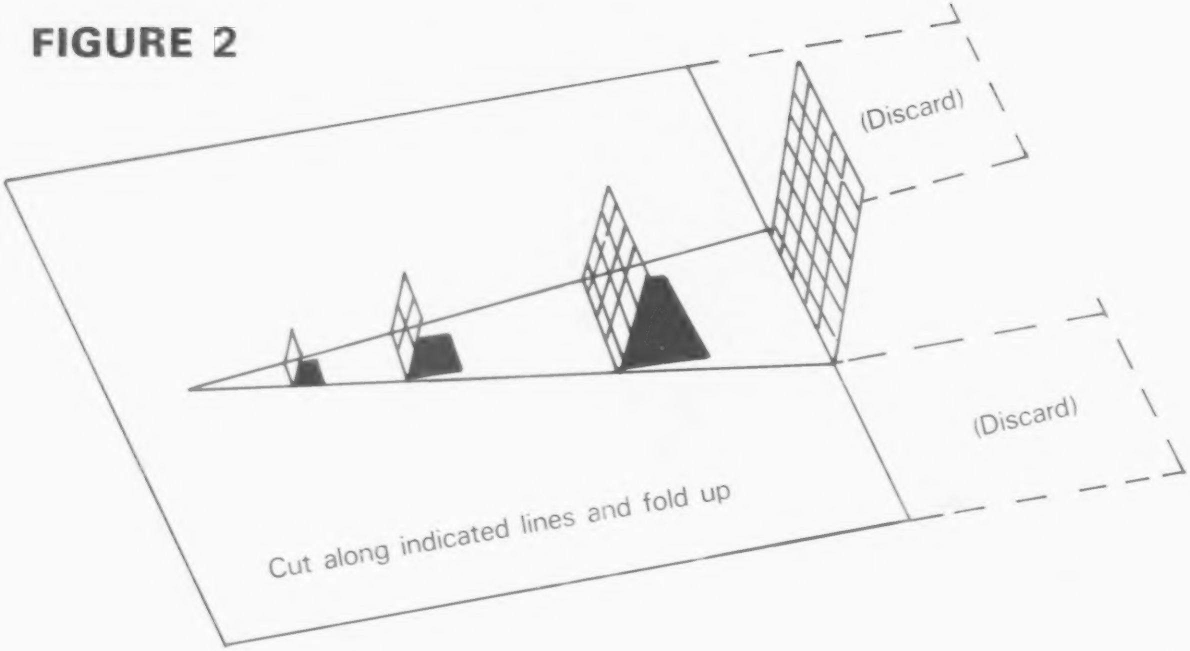
Cut along the three indicated sides;

fold up the grids on the indicated line.


(TOP)
cut
(Discard)
cut
cut
cut
cut
cut
cut
fold here
fold here
fold here
fold here
cut
cut
1"
2"
4"
cut
(Discard)

N-8

FIGURE 2


(Discard)
(Discard)
Cut along indicated lines and fold up

6-N

WORKSHEET

INVERSE SQUARE LAW
(Activity #2)

Instructions

1. Place a piece of paper on the ground. Decide on a "unit" distance, say 2 cm. Hold the spray can, without moving it, at that distance and give the piece of paper a shot of paint. Now move to another sheet of paper and hold the spray can at a distance of two "units" (e.g., 4 cm if you used 2 cm the first time) and spray again. Notice that it takes a little longer to get the same coverage as the first time. Repeat at three "units" and four "units." Record each distance from the paper in the table below.

2. Allow the paint to dry enough to make a measurement of the diameter of each circle of paint. Be sure to include all the drops of paint.

3. Record diameters. Use the following formula to calculate the area of the circle:

   $\text{Area} = \pi r^2$

   where pi = 3.14 and r = one half of the diameter of the circle of paint. Record areas.

4. Complete the table by recording the area ratios and calculating the squares of the products of ratios and distances

Circle #:	1	2	3	4
Distance from nozzle to paper				
Diameter of circle				
Area of circle				
Ratio of smallest area (#1) to each area				
Product of ratio and distance squared				

INVERSE SQUARE LAW
(Activity #3)

1. Turn on (warm up) the Geiger counter and measure the background radiation several times and get an average. The background is represented by the random clicks that represent cosmic rays from space and local natural radiation triggering the Geiger counter. (For those familiar with nuclear counting, the resolving time of the Geiger counter is ignored in this experiment.) Record the background count across the table below.

2. Position the radioactive source at the shortest distance to the Geiger counter tube that will produce a measurable number of clicks. This is our "unit" distance. Record the number of clicks at this distance.

3. Now move the Geiger tube to two times the "unit" distance and again record the number of clicks. Repeat this for three and four times the "unit" distance. Record data.

4. Complete the data table by correcting the radiation counts and calculating the ratios of corrected counts to inverses of distance squared.

Radiation Count Position #:	1	2	3	4
Distance (S)from tube to sample	______	______	______	______
Distance squared (^{2})	______	______	______	______
Background radiation	______	______	______	______
Total number of counts	______	______	______	______
Corrected counts (subtract) background from total)	______	______	______	______
Ratio of corrected counts to $1/s^2$	______	______	______	______

NUCLEAR PLANT: WHO DECIDES?

USE WITH:
Social Studies
Civics
General Science
Physics
Physical Science

TIME:
4 class periods

MATERIALS:
Worksheets
(included)

Objectives

In this roleplaying activity, students acquire skills and knowledge about decisionmaking by:

1. Analyzing a particular role and providing a rationale for his/her position.
2. Understanding there are no easy solutions, but many trade-offs.
3. Identifying various viewpoints about nuclear energy.

Background Information

The points of view given on the following pages describe the feelings of Townville residents about plans to locate a nuclear power plant 10 miles from the center of town. After a great deal of research and planning, the utility company, Power Incorporated, has decided this location has the best possible conditions for a plant. The electricity is needed to meet the future needs of the consumers of Townville as well as those in the surrounding area. There are, however, conflicting views by various members of the community. Some residents/businessmen can be considered special interest groups; others can be regarded as having an overall interest of maintaining their small, quaint community as is. Others waver from one point of view to another.

The town decides the best approach to take is the democratic one. All those with definite opinions would make the decision to work with Power Incorporated in constructing a plant or to ask the utility company to use their alternative site. The "no opinion" group has agreed to listen to the pro and con groups, as well as to the utility company, representatives from the Nuclear Regulatory Commission, and the mayor from Energyville, who has a nuclear plant near his town, before making a decision.

Procedure

1. Provide a schedule for the activities.

   Day 1 - Introduce, identify roles, assign research topics.
   Day 2 - Follow-up research.
   Day 3 - Hearing (5- to 8-minute presentations by each group).
   Day 4 - Discussion.

2. Assign roles:

    a. The "no opinions," the majority of the class
    b. Chamber of Commerce president
    c. School superintendent
    d. Audubon Society president
    e. Homeowner
    f. President of Power Incorporated utility
    g. NRC representative
    h. Mayor of Energyville
    i. Bank president
    j. Biologist for the U.S. Fish and Wildlife Service
    k. A facilitator (the mayor of Townsville)

3. Provide each role player with the student materials. The "no opinions" will not receive any information cards but will listen to all witnesses before making a decision. They may ask questions.

4. After each person has made his/her presentation, the "no opinions" will make their decision.

5. Follow with discussion.

Discussion

1. Have each group or individual present its strategy for swaying the "no opinions" to its side.

2. Were the groups able to satisfy all the different points of view?

3. What aspects of each group's plan benefited the entire community?

4. Have the opinions of the individuals changed during the process?

5. How can these techniques and skills be used in a real-life situation?

6. You may want to invite to the class any of the real people portrayed in the roles played by the students and interview that person or persons.

7. In order to demonstrate better the process, have students do a pre-game and post-game vote. Discuss why students did or did not change their opinions.

8. Discuss the role of the democratic process in deciding issues such as nuclear power.

    a. Identify other community issues which could be addressed through this process.

b. Do case studies of real situations where nuclear plants were located.

c. Discuss the pros and cons of employing this process of wide community involvement.

Points of View

1. President, Chamber of Commerce: After giving the project serious consideration, Mr. Wilson has chosen to ask Power Incorporated to choose the alternative site. Reason--Townville is a booming tourist town with beautiful lakes and rivers nearby for recreation activities, boating, fishing, and camping. The town has spent years in building its tourism business, which is its number one source of income. The tourism business has leveled off in the last five years and can be considered a constant source of income for the town. He fears a nuclear power plant would disturb this business and tourists would go elsewhere.

2. School Superintendent: Ms. Jones has decided to side with Power Incorporated and ask them to locate near Townville. Reason--Power Incorporated has developed a financial program to offset the increased number of people moving into the area during the construction phase, and many of these funds will go to the school system. Ms. Jones is in dire need of short-term, large amounts of money to renovate her schools. The high school gym needs a new roof and other repairs. Other needs are air-conditioning for the schools, new band uniforms, etc. Based on her discussion with the school superintendent in Energyville, Ms. Jones feels those schools were not severely affected by new students. She also believes the nuclear plant will be an advantage in the areas of science, physics, and social studies as an additional resource in facility as well as personnel.

3. Audubon Society President: Ms. Wells will ask Power Incorporated not to choose Townville or the alternative site, but to scrap the plans for a nuclear power plant and look to alternative energy sources that she feels will do less damage to the environment. Reason--Ms. Wells understands the need for additional energy in her region but feels a nuclear power plant has the potential for doing irreparable damage to the environment should an accident occur. Ms. Wells leans toward putting funds, research, and time into a program of solar power and conservation for long-term use.

4. Homeowner: Mr. Coat has made a decision not to make a decision. He has views both for and against the proposal and would like to use his time to express his concerns so that others may shed light on them in their presentation. Mr. Wells has several specific concerns; among them evacuation routes; accidental radioactive releases that could damage the water supply; and undesirable persons moving into his community and perhaps havingan economic impact on the individual homeowners.

5. President of Power Incorporated Utility Company: Mr. Simpson wants to locate his nuclear power plant in Townvile. Reasons--After a great deal of scientific research, his company has determined Townville is the ideal location. Not only does it meet the technological needs, such as a large supply of water, but also the social and economic needs of his company. There is plenty of room for Townville to grow to accommodate more houses, businesses, and new industries. It is a well-run town and the school systems and the recreational facilities--all primary concerns of his employees and their families--are excellent. Mr. Simpson cites examples of how closely he has worked with other communities in working out problems and meeting both the community's needs, and the utility's needs and promises to do the same with Townville.

6. Nuclear Regulatory Commission (NRC) Representative: Ms. Hall's role is not to be for or against but to ensure the proper steps have been taken. Ms. Hall explains that once an application for a permit to construct a nuclear power plant is received, NRC takes the following approach:

   Environmental Review: The National Environmental Policy Act requires an environmental review. Consideration is given to the effects of construction and operation of the plant on the local environment, and her agency weighs the benefits against the possible risks. This review takes into account views by experts in federal, state, and local governments as well as those of the public.

   Safety Review: The utility prepares a preliminary safety analysis report for the proposed reactor and data on the proposed site. This report includes hypothetical accident situations and safety features. While NRC staff members review this document, the advisory committee on reactor safeguards conducts a review, which is made public, and their recommendations are submitted to the commission. These reviews may require a year or more and may result in changes to the plant design.

   Public Participation: The law requires a public hearing before a construction permit is granted. The three-member Atomic and Safety Licensing Board, consisting of one lawyer and two technically qualified persons, presides. The board may consider the safety and environmental matters in one hearing or in separate hearings. The utility presents evidence in support of the proposed plant. NRC offers the safety report and/or final environmental statement. The public may appear to make statements or may formally petition the board to intervene as full participants. The board listens to all evidence and issues an initial decision to the Atomic Safety and Licensing Board Panel and to NRC.

   Anti-Trust Review: NRC conducts a pre-licensing anti-trust review to ensure the facility complies with anti-trust laws. Hearings may be recommended by the U.S. Attorney General or on petition of an interested party.

Construction Surveillance: NRC inspects during construction and reviews pre-operational testing to ensure the program meets requirements.

Operating License: Approximately two years before scheduled completion of the plant, the utility submits an application for an operating license. NRC again conducts a comprehensive safety review. A final environmental statement is issued. The commission publishes notice that it is considering issuance of a license. Each license for operation of a nuclear power plant contains technical specification for safety and environmental measures. NRC maintains surveillance of the plant throughout its lifetime.

7. Mayor of Energyville: Mayor Long has a nuclear power plant 25 miles from the center of his town, owned and operated by Energy Utility Company. Mayor Long has never regretted the power plant coming to Energyville community. Reasons: Unlike Townville, they had no major industries. The nuclear power plant brought in new revenue to the city schools and police and fire departments; new homes were built; commercial businesses were created, and five new industries have settled in this area. Mayor Long feels comfortable with the NRC regulations for safety and believes the Energy Utility Company goes above and beyond NRC standards for safety.

8. Bank President: Mr. Holston is definitely pro-nuclear plant. Reasons: Although he agrees with Mr. Wilson that the tourism industry is generating vast amounts of revenue, he does not feel a nuclear power plant will cause any decrease in tourism. He feels this large industry will bring new growth to the town, which will provide better services to the residents while maintaining the tranquility of the town.

9. Biologist for the U.S. Fish and Wildlife Service: Ms. Foster has no opinions as to whether the plant should or should not be built. She is here to discuss the environmental effects of the power plant. Ms. Foster is primarily concerned with release of excessive heat into the river. If this happens, it could be hazardous to the aquatic life. Although some accidental releases have been reported, they have been kept to a minimum. Ms. Foster feels that with the safeguards in place, such as cooling towers or cooling ponds, the risk is minimal.

A SIGN OF THE TIMES

USE WITH:
Physics
Physical Science
English
Social Studies
Art

TIME:
1 class period

MATERIALS:
Worksheets
(included)

Objectives

The student will understand:

1. The need for a communication system valid for 10,000 years.
2. That changes occur in languages over time.
3. The difficulty of developing a useful means of communicating an idea.

Background Information

Already, nuclear power plants are being decommissioned, that is, taken off line. When these plants are decommissioned, they may be dismantled and the highly radioactive parts may be buried or they may be covered in concrete. Highly radioactive nuclear waste is planned to be stored in deep underground repositories.

In these and other cases, the radioactive material must be prevented from coming in contact with the general public for many, many years. In thousands of years people may have solved the problem of waste disposal or people may not even be able to read!

Therefore, it is imperative that there be developed a satisfactory method of identifying the hazards of nuclear waste that is independent of written or spoken language. Sign language seems to be the answer, but what sign?

Procedure

1. This activity is an open-ended activity that allows students to develop their communicative skills. The provided word sheets will give students experience with the difficulty of interpreting symbols and identifying intelligible patterns from random samples. Have the students find the hidden words on the sheets. NOTE: Each of the 5 student worksheets uses the same words to find, but locations of the words are different on each worksheet.

2. Students may be divided into small groups responsible for developing ideas on how to communicate an idea to persons 10,000 years in the future. Allow students to brainstorm for 30 minutes; then have a representative of each group present the ideas.

3. Follow with discussion.

Discussion

1. Develop criteria for selecting the most effective communications system presented.

2. Have a contest and identify winners.

3. Examine and discuss examples of special communications efforts such as those developed for NASA.

4. As follow-up, the class may choose to send their suggestions to the U.S. Department of Energy; they are working on this problem, too.

5. Another interesting follow-up would be to investigate the diversity and origins of languages and their symbols.

ALPHA
CONTROL-ROD
DOSIMETER
PLUTONIUM
FUEL-ROD
REACTOR
NEUTRON
GEIGER
ENERGY
WASTE
RAD
CHAIN-REACTION
IRRADIATION
HALF-LIFE
GENERATOR
ELECTRON
COOLANT
NUCLEUS
X-RAYS
CURIE
BETA
REM
RADIOACTIVITY
YELLOW-CAKE
RADIATION
MILLIREM
GRAPHITE
FISSION
TURBINE
FUSION
GAMMA
CORE
NRC
CRITICAL-MASS
BACKGROUND
MODERATOR
CLADDING
ISOTOPE
URANIUM
BREEDER
PROTON
DECAY
ATOM
DOE

```
E P O T O S I P U U H Z U Z U X E N I B R U T Y H
Z S O L V H G F J X U T N A L O O C V J L T F G N
Y Q J E N F U Y Z Y Q Y N U C L E U S G A E K R O
Y Q V P M E M X C O N T R O L - R O D X R L R E I
Y T U L L L H Z P I M U I N A R U P O O - R M N S
D S V - Q A U A R E T E M I S O D W C E I R D E U
H C R W Z R Q T L E T S A W G R F I G J E K A B F
R O T A R E N E G F Y G N A N O R T C E L E M Y A
D N P E P D R R D M - Q Q I W S S U C I C A W P S
D N O W O E A N Q E M L M H Z S K Z U T R L D L C
U O I L W E D O X R O O I I E A U F R O N P O U G
V O E L H R I I M S Y B W F R M R L I U Q H R T N
N X T P E B O T R X V A Y E E - C O E D X A Z O P
N Y W R T O A A O I D C M N S L S X T Q A I D N B
E A M E I V C I T A J K S O A A H A C C J Y F I Z
K C C G H M T D A K E G O I U C W T G Y A O E U K
A E M I P O I A R K H R L T W I I O F R C E D M K
C D Q E A W V R E C W O Z A J T F M W J C Z R A Y
- A F G R B I Y D C E U E I I 1 C L A D D I N G S
W M I G G S T X O J V N M D R R E B N O R T U E N
O M S V D Q Y I M N V D P A C C J E I R B U J V D
L A S D M A N O I T C A E R - N I A H C R E M E V
L G I M W C R M Y Y Y N N R G H P G R X X N T R L
E X O F Z M P R O T O N L I Z S P E K W N W F A A
Y B N X C V I F S M M I L L I R E M V P Y G V O O
```

TEACHERS KEY #1

```
E P O T O S I . . . . . . . . . E N I B R U T Y .
. . . . . . . F . . . T N A L O O C . . . . . G N
. . . . . . U . . . . . N U C L E U S . . E . R O
. . . . . E . . C O N T R O L - R O D X R . . E I
. . . . L . H . . . M U I N A R U . . O - . . N S
. . . - . . . A R E T E M I S O D . C . . R . E U
. . R . . R . . L E T S A W . . . . . . . . A . F
R O T A R E N E G F . . . . N O R T C E L E . Y .
D . . . . D R . . . - . . . . S . . C . C A . P S
D . . . . E A N . . . L . . . S . . U . R L . L .
. O . . . E D O . . . . I . . A . . R . N P . U .
. . E . . R I I . . . B . F R M R . I . . H . T .
. . . . E B O T R . . A . E E - . O E . . A . O .
. Y . R T . A A O . . C M N . L . . T . . . . N .
E A . E I . C I T . . K . O . A . A . C . . . I .
K C . G H . T D A . . G . I . C . T . . A . . U .
A E . I P . I A R . . R . T . I . O . . . E . M .
C D . E A . V R E . . O . A . T . M . . . . R . .
- A F G R . I . D . . U . I . I C L A D D I N G .
W M I . G . T . O . . N . D . R . . N O R T U E N
O M S . D . Y . M . . D . A . C . . . . B . . . .
L A S . . A N O I T C A E R - N I A H C . E . . .
L G I . . . R . . . . . . R . . . . . . . . T . .
E . O . . . P R O T O N . I . . . . . . . . . A .
Y . N . . . . . . . M I L L I R E M . . . . . . .
```

WORKSHEET #2

ALPHA
CONTROL-ROD
DOSIMETER
PLUTONIUM
FUEL-ROD
REACTOR
NEUTRON
GEIGER
ENERGY
WASTE
RAD

CHAIN-REACTION
IRRADIATION
HALF-LIFE
GENERATOR
ELECTRON
COOLANT
NUCLEUS
X-RAYS
CURIE
BETA
REM

RADIOACTIVITY
YELLOW-CAKE
RADIATION
MILLIREM
GRAPHITE
FISSION
TURBINE
FUSION
GAMMA
CORE
NRC

CRITICAL-MASS
BACKGROUND
MODERATOR
CLADDING
ISOTOPE
URANIUM
BREEDER
PROTON
DECAY
ATOM
DOE

```
I N Q Y B H I Z N E T S A W T Z T O J J G P R C F
V E B K M H E Q G F F L T F C U A K U Q L R H P K
D Y E L L O W - C A K E B G K J R R W U V O S M N
O S R Q J Z V G X V K G T N P F A B T Z E T M U E
T D J L H J L U Y G R E N E O N Y O I V H C Q J U
O P K T Y H F T R R C A I F I I N A N N H A F X T
V Z N O I T A I D A R R I U M I T V C X E E R X R
F U E L - R O D S C D I M P U E Q A O E B R Y L O
F Q O F U S I O N S S I N M Y E R H I S D N U T N
T C O H F K R T D O I V O N V A E P W D N M S N M
J R T C E B G E T N H O J A C M Y L N L A E W A Z
E I X H H X P O D E A E N O C H R A A R H R R L T
T T H E Z A P Z F E H T N G A T I V E U V I O O F
I I O T M E I V U C E T P L M K I G J K D L T O T
H C K A T E B N L N R R F J A M I V M V Q L A C D
P A M U R R T A - O T - B W G E N O I O W I R I O
A L R L H Z D S L R L I C H G K E Z I T T M E C S
R - S Y R D V - Y I E U W P V N K C L N Y A D F I
G M S O I A R J F A R A X Y P K O S O X U F O I M
T A K N X O S E G I R S C K Q R K R R O R G M H E
C S G K D L N T E W Z - F T E F X S T A Z J O G T
N S E K Q R F U N I V S X J I G L G D C D M A M E
E R S Y C B A C K G R O U N D O X I F C E M C Z R
D O E S Z B V L T S U E L C U N N R Y A M L X U V
O G E N E R A T O R N O T O R P M N G A Y U E D M
```

TEACHER KEY #2

```
. . . . . . . . . E T S A W T . . . . . . P . . .
. . . . . . . . . . . . . . . U . . U . L R . . .
. Y E L L O W - C A K E . . . . R R . U . O . . N
. . . . . . . . . . . . . N . . A B T . . T . . E
. . . . . . . . Y G R E N E O N Y O I . . C . . U
. . . . . . F . R . . . . . I I N A . N . A . . T
. . N O I T A I D A R R I U M I T . C . E E . . R
F U E L - R O D S . D I M . U E . A . E . R . . O
. . . F U S I O N S S I . M . . R H I . D . . T N
. C . . . . R . . O I . O . . . . P . D . M . N .
. R . C . . . E T . . O . A C . . L . . A E . A .
E I . . H . . O D . . . N O C H . A . R . R R L .
T T . . . A P . . E . . N . A T . . E . . I O O .
I I . . . E I . . C E T . L . . I G . . . L T O .
H C . A T E B N L . R R F . . . I V M . . L A C D
P A . . . . . A - O . - B . . E . . I O . I R . O
A L . . . . D S L R L . C . G . . . . T T M E . S
R - . . . D . - Y I E U . . . N . C . . Y A D . I
G M . . I . R . F A R A . . . . O . . . . . O . M
. A . N . O . E . I R . C . . R . R R . . . M . E
. S G . D . N . E . . - . T E . . . T A . . . G T
. S . . . R . . . . . . X . I . . . . C D . A . E
. . . . C B A C K G R O U N D O . . . . E M . . R
D O E . . . . . . S U E L C U N N . . . M L . . .
. G E N E R A T O R N O T O R P . . . A . . E . .
```

WORKSHEET #3

ALPHA
CONTROL-ROD
DOSIMETER
PLUTONIUM
FUEL-ROD
REACTOR
NEUTRON
GEIGER
ENERGY
WASTE
RAD

CHAIN-REACTION
IRRADIATION
HALF-LIFE
GENERATOR
ELECTRON
COOLANT
NUCLEUS
X-RAYS
CURIE
BETA
REM

RADIOACTIVITY
YELLOW-CAKE
RADIATION
MILLIREM
GRAPHITE
FISSION
TURBINE
FUSION
GAMMA
CORE
NRC

CRITICAL-MASS
BACKGROUND
MODERATOR
CLADDING
ISOTOPE
URANIUM
BREEDER
PROTON
DECAY
ATOM
DOE

B C G K U E T P V P B Z U U R A N I U M X S G X L
Q P O W Y K U N P N O O E L E C T R O N J H C G K
R M D N U O R G K C A B S I T A T O M J S Q E K J
W I T C T I P I Q D M J K W H H A J C Y P H O G A
S L Y O R R J F L O O F M K X E P I T D A R D Y V
A L G T L N O G M N C S Y G P R E G I E G N R Y G
N I W N I S W L Q I N O I T C A E R - N I A H C Y
U R B R O V Z J - B R C R M G E N E R A T O R M A
C E X E Z T I B B R G R D O E Y E C B R W V F Y X
L M D M K P O T T N O O A V T T A Y E A X G X E A
E F U S I O N R C P D D M D O C E C N A G N Z L I
U C U E R P T E P A V R A I I Q A R E Y V I G L C
S X G E I Z Y W U M O H R V F A J E E D I D E O W
I - I H L G E B E T P I M O W V T J R B H D T W E
M R J A O - Y O A L R B D R P O J I V H Y A S - W
Z A A S R K R Q A V L O T A P F T F O P U L A C D
F Y U B G E G O H S U J N T R C E H L N P C W A A
I S X T S F I X D L F D I E O A R U C O R E G K H
S J X C R I T I C A L - M A S S T V A M M A G E L
S E P J G L F K Y G R E N E R O G R A P H I T E X
I B R P T - Y S P P F X K Q N M O D E R A T O R B
O P L J H F R E D E E R B I N F R A D I A T I O N
N A C O O L A N T G P V U S K T U R B I N E R Z U
G Q A Q V A M F C R F M M N H N Z I N E I R U C R
X N Y W I H E E P O T O S I O R K B E T A R M L
S

TEACHER KEY #3

```
. C . . . . . . . . . . . U R A N I U M . . . . .
. . O . . . . . . . . . E L E C T R O N . . . . .
. M D N U O R G K C A B . . . A T O M . . . E . .
. I . C T . . . . D . . . . . . . . . . . . O . .
. L Y . R R . . . . O . . . . . . . . D A R D . .
. L . T . N O . . . . S . . . R E G I E G . . . .
N I . N I . . L . I N O I T C A E R - N I A H C .
U R . R O V . . - . R . R M G E N E R A T O R . .
C E . E . T I . . R . R . O E Y . . . . . . . Y .
L M . M . . O T . . O . A . T T A . . . . G . E .
E F U S I O N R C . . D . D . C E C . . . N . L .
U . U . . . . E P A . . A . I . A R E . . I . L .
S X . E . . . . U . O H . . . A . E . D . D E O .
. - . . L . . . . T P I . . . . T . R . . D T W .
. R . . . - . . . L R . D . . . . I . . . A S - .
. A . . . . R . A . . O . A . . . . O P . L A C .
F Y . . . E . O . . . . N . R . . . L N . C W A .
I S . . . F . . D . . . . . . . . U C O R E . K .
S . . C R I T I C A L - M A S S T . A M M A G E .
S . . . . L . . Y G R E N E . O G R A P H I T E .
I . . . . - . . . . . . . . N M O D E R A T O R .
O . . . . F R E D E E R B I . . R A D I A T I O N
N . C O O L A N T . . . U . . T U R B I N E . . .
. . . . . A . . . . . M . . . . . . . E I R U C .
. . . . . H . E P O T O S I . . . B E T A . . . .
```

NOTE: DOE and NRC are found twice each on this word search puzzle.

ALPHA
CONTROL-ROD
DOSIMETER
PLUTONIUM
FUEL-ROD
REACTOR
NEUTRON
GEIGER
ENERGY
WASTE
RAD

CHAIN-REACTION
IRRADIATION
HALF-LIFE
GENERATOR
ELECTRON
COOLANT
NUCLEUS
X-RAYS
CURIE
BETA
REM

RADIOACTIVITY
YELLOW-CAKE
RADIATION
MILLIREM
GRAPHITE
FISSION
TURBINE
FUSION
GAMMA
CORE
NRC

CRITICAL-MASS
BACKGROUND
MODERATOR
CLADDING
ISOTOPE
URANIUM
BREEDER
PROTON
DECAY
ATOM
DOE

H	C	Z	E	N	I	B	R	U	T	N	Y	Y	C	U	N	Q	T	F	B	F	U	V	V	X
G	M	U	I	N	O	T	U	L	P	P	P	Y	K	C	O	N	T	R	O	L	-	R	O	D
Y	C	I	A	V	F	W	R	O	T	A	R	E	D	O	M	Y	O	E	D	P	J	X	Q	E
E	I	Q	U	L	I	F	N	E	U	T	R	O	N	O	C	U	Z	E	Y	Y	D	I	G	G
L	T	U	Q	H	A	M	R	O	T	A	R	E	N	E	G	U	C	L	V	D	R	O	A	X
L	C	A	F	R	J	W	E	F	I	L	-	F	L	A	H	A	R	O	K	R	F	M	Q	X
O	Y	G	R	E	N	E	O	X	P	U	J	Z	X	J	Y	U	S	I	A	S	M	Y	O	E
W	O	F	S	R	K	D	X	K	X	D	C	V	D	O	E	Y	T	D	E	A	Y	E	B	M
-	C	H	A	I	N	-	R	E	A	C	T	I	O	N	A	M	I	L	L	I	R	E	M	J
C	H	B	S	R	U	G	E	Y	S	B	Q	F	C	R	X	A	J	C	U	R	Y	F	M	M
A	Y	O	Y	I	E	P	T	X	S	X	R	R	-	A	T	U	G	B	E	I	E	C	H	C
K	W	V	Z	T	O	D	Z	T	B	D	I	X	T	I	Y	N	E	G	W	A	S	T	E	E
E	T	Q	Q	T	I	U	E	A	T	T	N	O	O	N	K	T	I	P	T	N	C	O	R	E
M	Z	T	O	L	R	V	C	E	I	O	M	N	E	B	A	E	G	D	O	A	L	P	H	A
W	I	S	G	A	W	K	I	C	R	J	Z	Q	U	D	G	S	E	I	S	Z	Y	Q	B	C
W	I	K	N	P	G	F	A	T	F	B	W	M	C	B	O	S	S	I	A	C	V	P	R	O
C	T	I	O	R	K	L	C	W	C	U	B	G	O	G	D	S	Q	P	J	R	R	N	R	A
D	U	L	O	P	-	E	O	C	M	A	E	G	Q	F	I	O	I	M	Q	O	T	G	A	Y
M	A	U	O	M	L	Q	O	R	R	L	O	L	W	F	T	Z	F	M	T	Y	W	E	D	F
O	N	V	A	E	Z	O	Q	G	A	E	L	I	-	K	C	D	A	O	E	V	O	F	I	D
D	C	S	K	I	L	C	Q	W	V	D	A	Q	D	R	M	D	N	U	J	T	E	H	A	T
Q	S	S	R	A	G	N	I	D	D	A	L	C	I	A	O	Q	D	Z	F	M	E	R	T	W
L	X	I	N	D	M	R	N	V	L	C	E	J	T	C	R	D	T	L	Z	L	Q	R	I	B
J	L	T	V	N	U	C	L	E	U	S	M	M	A	O	N	O	I	S	U	F	B	B	O	X

TEACHER KEY #4

```
. . . E N I B R U T . . . . . . . . . . . . . . .
. M U I N O T U L P . . . . C O N T R O L - R O D
Y . . . . . . R O T A R E D O M . . . D . . . . .
E . . . . . . N E U T R O N . C . . E . . . I . G
L . . . . . . R O T A R E N E G U C . . . R . A .
L . . . . . . E F I L - F L A H A R . . R . M . .
O Y G R E N E . . . . . . . . Y . S I A . M . . .
W . . . . . . . . . . . . D O E Y . D E A . . . .
- C H A I N - R E A C T I O N A M I L L I R E M .
C . . . R . . E . . . . . C R . A . . . R . . . .
A . . Y . E P . . . . . R - A T . . B E . . . . .
K . . . T O D . . B . I X T I . . E G W A S T E .
E . . . T I U E A . T N O O . . T I . . N C O R E
. . . O . R V C E I O M N . . A E . . O A L P H A
. . S . A . K I C R . . . . D G . . I . . . . . C
. I . N . G . A T F B . . . . O . S . . . . P R .
. . I . R . L C . C U . . . . . S . . . . R N R .
. U . O . - E . C . A E . . . I . I . . O . . A .
M . U . M L . O R R . O L . F . . . M T . . . D .
. N . A E . O . . A E . I - . . . . O E . . . I .
D . S . . L . . . . D A . D R . . N . . T . . A .
. S . . A G N I D D A L C . A O . . . . M E R T .
. . . N . . . . . . . . . T . R D . . . . . R I .
. . T . N U C L E U S . . . O N O I S U F . . O .
. . . . . . E T I H P A R G . R . . . . . . . N .
```

WORKSHEET #5

- ALPHA
- CONTROL-ROD
- DOSIMETER
- PLUTONIUM
- FUEL-ROD
- REACTOR
- NEUTRON
- GEIGER
- ENERGY
- WASTE
- RAD
- CHAIN-REACTION
- IRRADIATION
- HALF-LIFE
- GENERATOR
- ELECTRON
- COOLANT
- NUCLEUS
- X-RAYS
- CURIE
- BETA
- REM
- RADIOACTIVITY
- YELLOW-CAKE
- RADIATION
- MILLIREM
- GRAPHITE
- FISSION
- TURBINE
- FUSION
- GAMMA
- CORE
- NRC
- CRITICAL-MASS
- BACKGROUND
- MODERATOR
- CLADDING
- ISOTOPE
- URANIUM
- BREEDER
- PROTON
- DECAY
- ATOM
- DOE

R	A	E	G	Z	H	I	N	O	I	S	U	F	A	X	Y	T	L	F	U	G	E	Y	R	S
H	J	Q	B	N	E	L	E	C	T	R	O	N	I	E	U	T	A	T	I	N	I	C	E	M
D	R	N	R	I	C	X	A	J	G	B	Q	M	L	R	W	G	Z	L	E	S	H	J	A	B
L	Z	W	E	U	F	O	H	U	F	J	E	L	B	T	X	U	H	R	V	A	S	U	C	Z
U	W	J	E	G	J	M	P	Q	Z	H	O	I	B	T	A	J	G	P	I	F	E	I	T	C
R	U	C	D	U	C	B	L	Z	X	W	N	R	B	U	R	Y	X	N	N	G	F	R	O	T
A	C	I	E	M	S	R	A	Q	-	E	E	E	C	P	R	P	-	J	B	X	I	N	R	N
N	I	O	R	A	X	J	I	C	K	M	U	S	Y	E	R	R	X	Q	F	Z	L	C	Z	B
I	G	D	R	Z	C	B	A	T	L	A	J	I	T	S	E	O	X	S	A	A	-	M	J	R
U	E	N	A	E	O	K	F	R	I	M	F	E	Z	A	Z	E	T	G	Y	E	F	V	U	Y
M	N	U	K	Y	E	G	X	H	Q	C	M	N	C	K	T	Y	T	O	O	N	L	K	W	V
D	E	O	N	O	B	E	E	I	R	I	A	T	O	I	S	O	A	N	N	A	A	L	A	A
P	R	R	B	L	S	I	F	A	S	A	I	L	H	I	T	U	A	T	A	Y	H	Z	S	X
W	A	G	C	S	D	G	Z	O	C	O	D	P	-	C	T	Z	E	O	O	L	Q	T	T	R
E	T	K	D	T	O	E	D	M	N	C	A	B	D	M	L	A	Q	L	U	M	O	B	E	O
P	O	C	I	H	E	R	J	E	Q	R	X	A	A	X	A	A	I	L	C	E	M	O	S	T
O	R	A	S	X	M	J	C	G	G	J	J	M	R	D	D	S	D	D	J	U	X	A	C	A
T	J	B	A	K	R	T	U	U	H	X	U	Z	N	M	E	N	S	D	A	J	N	N	O	R
O	G	R	S	O	M	Q	S	U	R	Q	I	Y	F	C	S	C	R	M	I	R	Z	K	V	E
S	F	Y	Q	C	A	M	M	A	G	I	G	W	H	Y	L	X	A	C	R	N	Q	A	S	D
I	W	M	U	I	N	O	T	U	L	P	E	D	F	E	P	N	K	Y	X	S	G	V	S	O
A	Z	J	A	T	E	B	P	H	Y	T	I	V	I	T	C	A	O	I	D	A	R	S	Y	M
I	R	R	A	D	I	A	T	I	O	N	E	N	Y	S	I	S	M	I	L	L	I	R	E	M
V	B	G	I	S	Y	A	R	-	X	J	C	O	N	T	R	O	L	-	R	O	D	P	A	O
U	F	R	Y	S	A	M	T	Y	F	U	E	L	-	R	O	D	N	E	U	T	R	O	N	Q

TEACHER KEY #5

```
. . . . . . . . . N O I S U F Y T . F . . E . R .
. . . B . E L E C T R O N . E U . . . I N . C E .
. . . R . . . A . . . . . L R . . . . E S H . A .
. . . E . . . H . . . . L B . . . . R . A S . C .
U . . E . . . P . . . O I . . . . G . I . E I T .
R . . D . C . L . . W N R . . . Y . N . . F . O .
A C . E . . R A . - E E . . P R . - . . . I . R N
N . O R . . . I C . M . . . E R R . . . . L . . .
I G D R . . . A T . . . . T . E O . . . . - . . .
U E N . E . K . . I . . E . A . E T . . . F . . .
M N U . . E G . . . C M N C . T . T O . . L . W .
. E O . . . E . . R I A T O I S . A N N . A . A .
. R R . . . I . . S A I L H I . U . T A . H . S .
. A G . . D G . O . O D P - C T . E . O L . . T R
E T K . . O E D . N . A . . M L A . L . M O . E O
P O C . . E R . . . R . . . . A A I . C . . O . T
O R A . . . . C . G . . . . D . S D D . U . . C A
T . B . . . . . U . . . . . . E N S D A . N . . R
O . . . . . . . . R . . . . . . C R . I R . . . E
S . . . . A M M A G I . . . . . . A C . N . . . D
I . M U I N O T U L P E . . . . . . Y . . G . . O
. . . A T E B . . Y T I V I T C A O I D A R . . M
I R R A D I A T I O N . . . . . . M I L L I R E M
. . . . S Y A R - X . C O N T R O L - R O D . . .
. . . . . . . . . F U E L - R O D N E U T R O N .
```

DECAYING DOTS

USE WITH:
General Science
Physical Science
Environmental Science
Applied Chemistry

TIME:
1 class period

MATERIALS:
Scissors
Graph paper
French curve (optional)
Worksheets (included)

Objectives

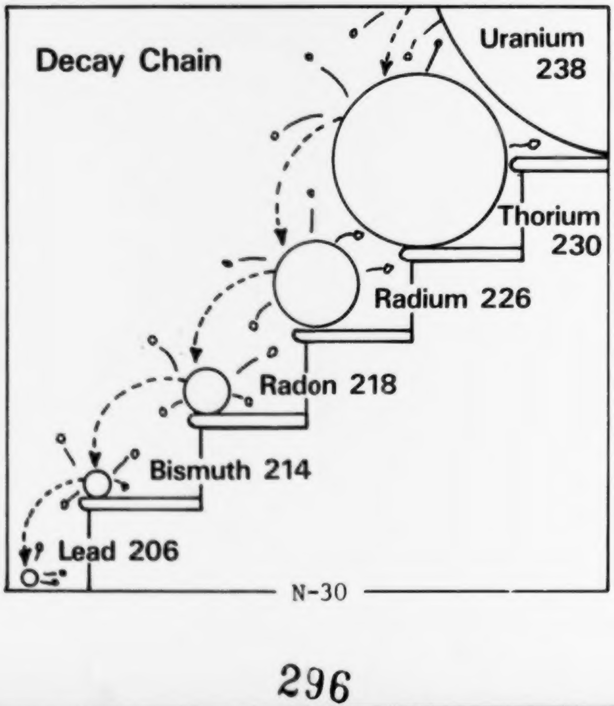
The student will:

1. Develop knowledge of the concept of "half-life."
2. Calculate the amount of time for radioactive substances to decay.
3. Use graphing skills to show the rate of decay.

Background Information

An atomic nucleus continues to emit nuclear radiation until a stable nucleus is formed. As a radioactive substance decays, it changes from one nuclear substance to another. This process of radioactive decay is called transmutation. For example, U-238 transforms into Thorium-230, then Radium-226, and so on until eventually a stable isotope of lead is formed. (See figure 1.) This process is called a decay chain. The rates of decay vary from isotope to isotope and can range in time from seconds to billions of years. Effective half-life is the time required for a radioactive substance to reduce its activity by half as a result of radioactive decay. Half-life is also defined as the period of time during which half the atoms in a radioactive sample will undergo radioactive disintegration. (See table 1.) The following activity will provide insight into these processes.

Figure I



HALF-LIVES OF SOME COMMON ISOTOPES

Americium 241	475 years
Californium 252	2.2 years
Carbon 14	5,760 years
Hydrogen 3 (Tritium)	12.26 years
Iodine 131	8 days
Krypton 85	10.6 years
Phosphorus 32	14.29 days

TABLE 1

Procedure

1. Introduce the activity by defining half-life.
2. Explain to the students the purpose of this activity is to simulate the radioactive decay of a substance.
3. Distribute the worksheet with student instructions and the dotted paper.
4. Ask students to read instructions before beginning. Answer any questions concerning activity.
5. Once the students have completed the activity follow with discussion.

Discussion

1. Suppose that the original number of dots represented one kilogram (1000 grams) of an isotope of Strontium, e.g., Sr-90. What mass of Sr-90 would be left at the end of the fourth half life period? How is this calculated?

2. Strontium-90 is a by-product of the fission of Uranium-235. Sr-90 has a half-life of 28 years. How long would it take the original one kilogram mass of Sr-90 to decay to 125 grams of Sr-90?

3. For follow-up or enrichment, these are suggested:

   A. For each type of scientist listed below, find at least one use he would have for the concept of half-life. In other words, how could each scientist use the half-life of radioactive substances in the research he performs?

      1. Geologist
      2. Chemist
      3. Biologist
      4. Physicist
      5. Others

B. Students might wish to contact TVA's Citizen Action Office to ask for more information on low-level and high-level radioactive materials found in nuclear power plants. Call toll-free 1-800-362-9250 (Tennessee), 1-800-251-9242 (Alabama, Georgia, Kentucky, Mississippi, North Carolina, Virginia), or 632-4100 (Knoxville), or write 400 West Summit Hill Drive, Knoxville, Tennessee 37902.

Instructions

1. Count the number of dots on the accompanying sheet and record in the data table opposite 0 divisions. This number represents the original number of atoms in your radioactive sample.

2. Cut the sheet exactly in half and discard one of the halves. The remaining half represents the number of atoms of the original radioactive sample that should be left after one half-life period. Record the number of dots on this sheet opposite 1 on the data table. Repeat this procedure (cutting, counting, recording) until there is only one dot left.

DATA TABLE II

Number of Divisions	Number of Dots Left

3. Using a sheet of linear graph paper, plot a graph showing the rate of decay. First, label the x-axis (horizontal) as number of divisions. Next, label the y-axis (vertical) as the number of atoms of the original sample left. Using a French curve (device used by draftsmen in drawing curved lines) carefully draw a smooth line connecting the plotted points. If a French curve is not available, draw as smooth a line as possible. Be sure to title your graph appropriately.

****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****
****

NUCLEAR PURSUIT

Objectives

The student will:
1. Identify key nuclear terms and and define them.
2. Become familiar with historical events and persons in nuclear science.
3. Become aware of the facts concerning nuclear power in the Tennessee Valley.

USE WITH:
Physical Science
General Science
Physics
Social Studies

TIME:
2 class period

MATERIALS:
Game board
4 bottle caps
10 beans or tokens
One die
Worksheets (included)

Background Information

The 1960s and 1970s were decades of social and economic change throughout the United States and the world. The Middle East oil embargo forced a look at alternative energy sources.

The United States is the world's leading producer of nuclear energy, natural gas, and coal. The Tennessee Valley Authority began its nuclear construction phase in 1966, with commercial operation beginning in 1974 at Browns Ferry Unit 1, located in northern Alabama.

Compared to fossil fuels and hydropower, nuclear energy has a short history as an energy source. Nuclear energy is also a more specialized energy source in that its sole purpose to date has been for the production of electricity.

Many concerns surrounding nuclear energy arise from questions that as yet have no answers; the nuclear age has a short history. Other concerns are caused by lack of knowledge and awareness. This activity will provide an overall view of nuclear energy in the terms and concepts needed for an understanding of this energy source.

Procedure

1. To prepare for Nuclear Pursuit, provide each student with a fact sheet to study. Definitions of terms may be found in the glossary and the student worksheet. Make these available to each student.

2. This activity can be used by a small group of students or by the class as a whole. The set of 80 questions is sufficient for most groups with a basic knowledge of nuclear energy concepts. It can be used as a test review by adding to each category a few questions applicable to the concepts covered by the test. If used by a small group, the printed gameboard should be used. If used by the entire class, the gameboard should be projected on a screen or wall. One person, called the reader, is needed to give out the questions. This is usually the teacher if the entire class is participating.

3. Rules of the game:

    a. The game is to be played with 2 to 4 players or 2 to 4 groups of players. Each player (or group) rolls the die to determine who goes first.

    b. The object of the game is to get to the center of the gameboard and answer one final question correctly. Players must stay on the outer edge of the board until they capture 3 neutrons. Movement is made by rolling the die. Players may move the number of spaces equal to the number on the die and in any direction around the edge.

    c. The reader gives the question, and the player (or group) has 60 seconds to respond. Only one answer may be given. If incorrect, the next player (or group) rolls the die and moves to the new position. If a correct answer is given, the player or group may roll again to move to a new position and receive another question. If the position is marked NEUTRON, a correct answer will capture a neutron (token or bean). The player (or group) must stop after capturing a neutron and await his next turn.

    d. After capturing the third neutron, a player (or team) may move down toward the core with his next roll(s). The core is to be reached on an exact number from the die. If the core question is missed, he/she must wait until his/her next turn to receive another one. The first player (or team) to answer a core question correctly wins. The core question may come from any of the four categories. The player (or group) trying to answer the question chooses which category.

4. The questions follow. Correct answers are given in parentheses. Supervise the game according to the given procedure.

5. Follow with discussion.

Discussion

1. Compare and contrast a nuclear power plant to fossil fuel plants with reference to their respective advantages and disadvantages.

2. Project possible energy sources to meet our energy needs as fossil fuels become less available.

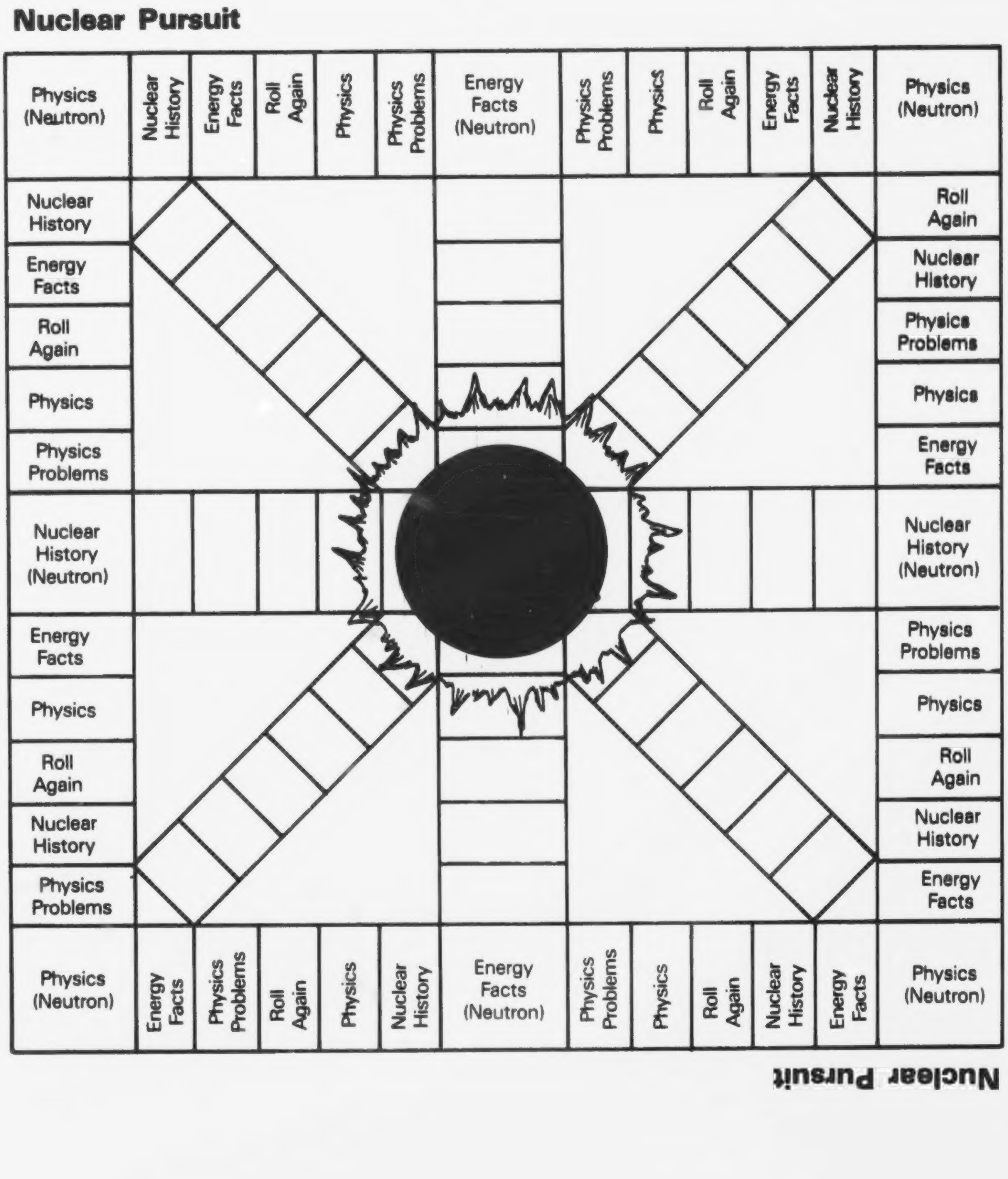
3. Using a map of the United States, locate existing and planned nuclear power plants.

4. These are suggested follow-up lessons:

    a. Arrange a visit to a power plant, preferably a nuclear plant.

    b. Invite a representative of a power-generating agency or company to make a presentation to your class.

    c. Invite someone opposed to nuclear power to visit your class and explain his/her opposition to this energy resource.


Nuclear Pursuit
Physics (Neutron)
Nuclear History
Energy Facts
Roll Again
Physics
Physics Problems
Energy Facts (Neutron)
Physics Problems
Physics
Roll Again
Energy Facts
Nuclear History
Physics (Neutron)
Nuclear History
Energy Facts
Roll Again
Physics
Physics Problems
Nuclear History (Neutron)
Energy Facts
Physics
Roll Again
Nuclear History
Physics Problems
Roll Again
Nuclear History
Physics Problems
Physics
Energy Facts
Nuclear History (Neutron)
Physics Problems
Physics
Roll Again
Nuclear History
Energy Facts
Physics (Neutron)
Energy Facts
Physics Problems
Roll Again
Physics
Nuclear History
Energy Facts (Neutron)
Physics Problems
Physics
Roll Again
Nuclear History
Energy Facts
Physics (Neutron)
Nuclear Pursuit

NUCLEAR PURSUIT QUESTIONS

Energy Facts Category

1. What is the leading nuclear power-producing country? (U.S.)

2. What is the most important commercial use of nuclear energy today? (Production of electricity)

3. Who owns most U.S. nuclear power plants? (Private utility companies)

4. Nuclear power plants release small amounts of radioactive gas into the air. (true or false) (true)

5. What agency regulates the production of nuclear power in the U.S.? (NRC - Nuclear Regulatory Commission)

6. What is the problem with the waste materials produced by nuclear power plants? (radioactive)

7. Within 5 percent, what percentage of electricity produced in the Tennessee Valley is generated using nuclear power? (0 percent in 1986; 16 percent in 1985)

8. What are capital costs? (costs incurred during construction)

9. Which type of generating plant uses less fuel per kWh of electricity produced - coal-burning, oil-burning, or nuclear reactor? (nuclear reactor)

10. Generally, which form of nonrenewable energy use is the most pollution free? (nuclear)

11. Uranium is a nonrenewable source of energy. (true or false) (true)

12. Where are the sites of completed nuclear power plants in the Tennessee Valley? (Sequoyah, near Chattanooga, Tennessee and Browns Ferry, near Decatur, Alabama)

13. Most radioactive wastes produced today are produced by nuclear reactors. (true or false) (false)

14. Approximately what percentage of natural uranium is fissionable? (1 percent)

15. According to most experts, how much more energy will we need in the year 2000 as compared to today? (double)

16. To the nearest million, how many kWh of electricity were produced by nuclear power in 1985 in the Tennessee Valley? (17,704 million kWh)

17. What is the known U.S. tonnage of reserves of uranium? (980,000 tons)

18. Where is most of the uranium found in the U.S.? (western states)

19. What are the five major steps in the fuel cycle? (mining, milling, enrichment, fabrication, and power plant)

20. How many fuel rods are needed for a power plant? (200)

NUCLEAR PURSUIT QUESTIONS

Physics Problems Category

1. Radioactive isotope A has a half-life of one year, while radioactive isotope B has a half-life of one day. Which one will give the highest reading on a Geiger counter? (B)

2. When heavy elements such as uranium undergo fission, what can you say about the total mass of all the remaining particles as compared to the mass of original uranium atoms? (less)

3. Suppose that somehow an atomic bomb was exploded in a box which was able to contain all the energy released by the bomb. How does the mass of the remaining material in the box compare to that of the original bomb? (less)

4. When a radioactive atom decays, it turns into: (a) an isotope, (b) an ion, or (c) a different element? (c)

5. How many neutrons are in the carbon-14 atom? (8)

6. What type of "ray" originates in the cosmos? (cosmic ray)

7. What is the mass number of an atom that contains five protons and six neutrons? (11)

8. A beta particle is another name for what? (an electron)

9. Nuclear chain reactions are self-sustained by the release of what type of particles? (neutrons)

10. What are elements called that have the same number of protons but different numbers of neutrons? (isotopes)

11. How many nucleons are in N-15? (15)

12. An alpha particle is another name for what? (a helium nucleus)

13. As the distance from a radioactive source decreases, how will the intensity of radiation from the source be affected? (increase)

14. The half-life of radium is 1,600 years. How much of a 16-gram sample of radium will remain after 3,200 years? (4g)

15. What do alpha particles consist of? (2 neutrons and 2 protons)

16. The half-life of carbon-14 is 6,000 years. How much of a 100-gram sample will remain after 12,000 years? (25g)

17. What happens to the total mass and the total charge in nuclear equations? (mass decreases, charge remains the same)

18. A radioactive element has a half-life of 15 days. How long will it take a 60-gram sample to decay to 15 grams? (30 days)

19. A particle emitted by a radioactive substance is attracted to a negatively charged plate. What is the particle? (alpha particle)

20. Plutonium has an atomic mass of 210 and an atomic number of 84. If it spontaneously gave off an alpha particle, it would form a new element with a mass number of what? (206)

NUCLEAR PURSUIT QUESTIONS

Nuclear History Category

1. In what city was the first chain reaction produced? (Chicago)
2. In what country was the first nuclear power plant put into operation? (England)
3. In what year did the first U.S. nuclear power plant open? (1957)
4. Rounded to the nearest 50, approximately how many nuclear power plants are operating worldwide? (400)
5. Who discovered natural radioactivity? (Becquerel)
6. Who discovered the nucleus of the atom? (Rutherford)
7. Who discovered the neutron? (Chadwick)
8. Who were the two German scientists who actually split the first uranium atom? (Hahn and Strassmann)
9. Who were the Austrian physicists who described the first successful fission experiment? (Meitner and Frisch)
10. Who headed the team that accomplished the first artificially created chain reaction? (Fermi)
11. Near what city are the Fermi Labs located? (Chicago)
12. To the nearest 10, how many nuclear power plants are now operational in the United States? (102)
13. Who discovered radium? (the Curies)
14. In what year did Einstein propose the equivalence of mass and energy? (1905)
15. What type of reactors are found in the Tennessee Valley? (PWR and BWR)
16. In what state did the first U.S. commercial nuclear power plant begin operations? (Pennsylvania)
17. In what type of athletic structure was the first controlled chain reaction achieved? (football stadium)
18. Who discovered deuterium? (Urey)
19. What famous scientist associated with nuclear physics escaped Italy by not returning from his trip on which he accepted the Nobel Prize? (Fermi)

NUCLEAR PURSUIT QUESTIONS

Physics Category

1. As the nucleus splits, it releases energy largely in what form? (heat)
2. What is the fuel most often used in nuclear power reactors?
3. What is the heaviest naturally occurring element? (Uranium)
4. What is the only type of nuclear reaction that is controlled by people to produce energy? (fission)
5. What is the more abundant isotope of uranium that is not fissionable? (U-238)
6. How many protons are in uranium atoms? (92)
7. Two protons and two neutrons combine to form what type of nuclear radiation? (alpha particles)
8. What is produced in the nucleus when a beta particle is emitted? (proton)
9. Which type of radioactivity is in the form of electromagnetic radiation? (gamma)
10. What particle is used to split an atom in a nuclear reactor? (neutron)
11. Which naturally-occurring element is the easiest to split? (uranium)
12. What is the purpose of a moderator in a nuclear power plant? (slow down neutrons)
13. Name a common uranium ore in which both U-235 and U-238 occur. (carnotite or pitchblende)
14. Name an element that is commonly used in control rods. (boron or cadmium)
15. Which type of radioactivity has the most energy? (gamma)
16. Are most nuclear power plants lightwater reactors or heavywater reactors? (lightwater reactors)
17. What is the name of the black powder used to make the pellets used in most fuel rods? (uranium dioxide)

18. The amount of fuel needed to sustain a chain reaction is called what? (critical mass)

19. Warm wastewater from a nuclear reactor can cause what type of pollution? (thermal pollution)

20. What is the name given to the process of rapidly inserting control rods into the core to shut down a reactor during an emergency? (scramming)

NUCLEAR PURSUIT FACT SHEET

- December 2, 1942, in a football stadium in Chicago, Illinois, a group of scientists led by Erico Fermi produced the first chain reaction.

- England was the first country to operate a nuclear power plant. Not until 1957 did the U.S. put a nuclear power plant into operation (in Pennsylvania).

- To date, there are approximately 400 nuclear power plants in operation worldwide, with 102 of those located in the U.S.

- Several of the scientists associated with nuclear science are listed below:

  Becquerel: discovered radioactivity

  Rutherford: discovered the nucleus of the atom

  Chadwick: discovered the neutron

  Hahn/Strassman: German scientists who actually split the first uranium atom

  Meitner/Frisch: Austrian physicists who described the first successful fission experiment

  The Curies: discovered radium

  Einstein: in 1905, proposed the equivalence of mass and energy, $E = mc^2$

  Urey: discovered deuterium

  Fermi: led the team of scientists who produced the first chain reaction (Fermi escaped Italy during World War II by not returning from the trip on which he accepted the Nobel Prize.)

- The U.S. is the leading nuclear power-producing country. Private utility companies own most of these nuclear power plants. The Tennessee Valley Authority has operated several nuclear power plants in its seven-state region.

- The Tennessee Valley Authority's nuclear power program produced 17,704 million kWh of electricity in 1985 for approximately 16 percent of the total power production in the Valley.

- A main use of nuclear power is the production of electricity.

- Nuclear energy is a highly controversial energy source. The Nuclear Regulatory Commission (NRC), a federal agency, regulates all power plants in the U.S. Major concerns about nuclear energy are the release of small amounts of radioactive gas into the atmosphere and the radioactive waste produced by nuclear power. Another concern is thermal pollution; heated water from nuclear plants, released back into rivers and streams, can cause damage to aquatic life.

- Nuclear energy's fuel costs are less than those for coal or oil. Major financial costs are construction, capital, and operational costs.

- Uranium, a nonrenewable source, is the principal element that provides the fuel for nuclear power. Only one percent of natural uranium is fissionable.

- There are approximately 980,000 tons of known reserves of uranium located in the Western states.

- Uranium-235, the fissionable isotope of Uranium, is bombarded by neutrons to cause the atomic nucleus to split, releasing a tremendous amount of energy. This process is called fission. Only the enriched U-235 is fissionable, not the more abundant U-238.

- A moderator, usually heavy water or graphite, is used to slow the fast-moving neutrons down. Control rods made of boron or cadmium are used to absorb the neutrons. Control rods can be inserted rapidly to shut down a reactor through a process called scramming.

- Most nuclear reactors are lightwater reactors (LWR). Two types of LWR that are used in the Tennessee Valley are Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR).

- Atoms are made up of protons, neutrons, and electrons. In U-235, there are 92 protons, 143 neutrons, and 92 electrons in each atom.

- Three types of radiation are released from radioactive elements: alpha, beta, and gamma. When a beta particle is emitted from a nucleus, a proton is produced. Two protons and two neutrons form an alpha particles. Gamma rays contain the most energy.

- The amount of fuel needed to sustain a chain reaction is called a critical mass.

- In some cases, the shorter the half-life of a radioactive substance, the higher the reading on a Geiger counter (i.e., higher levels of radiation are given off).

- When a heavy element such as uranium undergoes fission, the total mass of its products are less than the original mass.
- Through the process of radioactive decay, one substance changes to another element.
- The number of protons and neutrons in an atom is the mass number of an atom.
- Beta particle is another name for an electron.
- Atoms that have the same number of protons but a different number of neutrons are called isotopes.
- Alpha particle is another name for a helium nucleus.
- Half-life is the length of time during which half the atoms will disintegrate. Carbon-14 has a half-life of 6,000 years. One gram of carbon-14 would be reduced to 1/2 gram of radioactive material after 6,000 years.

USE WITH:
Physical Science
General Science
Earth Science

TIME:
2 class periods

MATERIALS:
Magic markers
Long sheets of paper (e.g., from a roll of white butcher paper)

FUEL CYCLE

Objectives

The student will:

1. Identify the five major steps in the fuel cycle.
2. Trace the steps in the fuel cycle.
3. Define the major terms associated with the fuel cycle.

Background Information

In a conventional reactor U-235 is the fuel used to create heat energy to produce steam that eventually generates electricity. U-235 is a naturally-occurring isotope of uranium, most of which is the U-238 isotope. Uranium deposits are found in Africa, Australia, Europe, Canada, and the western United States.

Because uranium ore is slightly radioactive, it can easily be detected by sensitive instruments. After a deposit has been found and its size and value determined, mining may begin. The ore is mined much the same as is coal, by surface mining, underground mining, or solution mining. On the average, one ton of ore yields four pounds of uranium oxide (U_3O_8). Of that four pounds only 0.7 percent is the sought-after, fissionable Uranium-235. Through the milling process the ore is refined and concentrated into a product called yellow-cake. In a uranium conversion facility, the yellow-cake is treated with hydrofluoric acid and fluorine to produce a gas-uranium hexafluoride (UF_6). This gas is cooled to a solid and shipped to one of the enrichment facilities owned by the Department of Energy. These facilities are in Paducah, Kentucky; Oak Ridge, Tennessee; and Portsmouth, Ohio.

The enrichment process is the most difficult step in the cycle. The solid UF_6 is heated until it once again becomes a gas. U-235 and U-238, both present in the UF6, are separated in a process called diffusion. In this process, the isotopes pass through a porous barrier. Because U-235 moves faster than U-238, U-235 molecules will strike the barrier more frequently and more U-235 molecules will pass through the barrier. As the U-235 vapor passes thorugh the porous barrier, it is slightly enriched. This must be repeated thousands of times in order for the gas to be enriched to 3 percent for use in a nuclear power plant.

The U-235 gas is allowed to cool and form a solid before being shipped to a fabrication plant. At the fabrication plant the enriched uranium is converted to uranium dioxide (UO_2) powder and pressed into pellets 3/8-inch in diameter and about 1/2-inch long. The pellets are inserted end-to-end into a 12- to 14-foot-long metal tube made of a zirconium alloy and called a fuel rod. Rods are bound together in bundles and shipped to the plants.

Procedure

1. Discuss with the students the steps of the fuel cycle.
2. Divide the class into groups of 4 or 5. Provide each groups with paper about 10 feet long and 2 feet wide and magic markers in various colors.
3. Ask each group to work together as a team to trace the steps in the fuel cycle using graphics such as sketches. Ask them to be detailed in their drawings, identifying what happens in each step and labeling where necessary.
4. Have each group present its mural to the class, explaining the fuel cycle and the representation of it on the mural.
5. Follow with discussion.

Discussion

1. Calculate the amounts of uranium and of U-235 that could actually be separated from one ton of uranium ore. Try these calculations for differing amounts of ore. Do the calculations using metric units, or convert the answers from the first set of calculations to metric units.
2. Is uranium enrichment a complicated process? Does it seem likely that the fuel cycle itself consumes much energy? How does the energy gained from uranium fuel compare to the energy required to produce that fuel? (Students may research specific answers to these questions for enrichment or extra credit.)
3. Discuss the relationships of energy, mining, and environmental concerns in respect to the nuclear fuel cycle.
4. As follow-up, students may explore the variety of careers within nuclear energy operations.

POWER PLANT CYCLE

USE WITH:
General Science
Physical Science

TIME:
2 class periods

MATERIALS:
Worksheets
(included)

Objectives

The student will:
1. Identify the major components of a nuclear power plant.
2. Simulate the workings of a nuclear power plant.
3. Understand how electricity is generated by a nuclear power plant.

Background Information

In a conventional nuclear power plant, the heat used to create steam is produced by the fission of U-235 atoms. In this process, so much heat energy is released that each fuel pellet, weighing one-third ounce, can generate as much electricity as 1,600 pounds of coal. A self-sustaining chain reaction occurs when the number of neutrons released in a given time equals or exceeds the number of neutrons lost by absorption.

The creation of this immense heat takes place in and is contained by the reactor vessel. Two types of reactors are used in the Tennessee Valley--the Boiling Water Reactor (BWR) and the Pressurized Water Reactor (PWR). In a BWR, the steam generated in the reactor vessel is used directly to drive the turbines; in the PWR, heat is transferred through a primary loop from the reactor to a heat exchanger by water kept under high pressure to achieve high temperature without boiling. The steam generated in the secondary circuit is then sent to the turbine.

The energy imparted by the expanding steam rotates the turbines. The turbines connected to a generator cause the rotor coils to rotate at approximately 1,800 revolutions per minute. As the rotor coils pass stator (stationary) coils, alternating current is produced. The electrical energy produced is sent through transformers and over power lines to homes, commercial businesses, and industries.

Procedures

1. Distribute student materials. Using the schematics of nuclear reactors, explain the process by which nuclear energy is converted to electrical energy for every-day usages.

2. Students will role-play as components of a nuclear reactor. Each student will be given a station assignment and a card naming his/her particular component role. If more than one student is needed for a component, a group leader should be named. The students or group leader will have to describe the function of his particular component. (Numbers of students may be adjusted according to class size.)

3. The following components are needed:

   a. Reactor Vessel: 4 or 5 students standing in a circle holding hands.

   b. Fuel Rods: 2 or 3 students standing in the circle; they are not to move.

   c. Control Rods: 2 students inside the circle. They may raise or lower their arms to indicate lowering and raising of the control rods.

   d. Steam Generator: 5 or 6 students holding hands, standing in an oval shape. Two more students will be needed to connect the reactor vessel to the steam generator. (If a BWR is being depicted, omit this component.)

   e. Steam Line: 3 or 4 students to connect the steam line from the steam generator to the turbines.

   f. Turbine: 2 or 3 students, arms outstretched, moving in circles.

   g. Generator: 3 or 4 students making a circle.

   h. Rotor Coils: 1 student inside the generator, moving in a circle.

   i. Stator Coil: 1 student inside the rotor coil circle; must not move.

   j. Pump and Steam Lines: 5 or 6 students to connect generator with steam generator.

   k. Transformers: 1 or 2 students acting as transformers and transmission lines.

   l. Consumer: Student using electrical appliance.

   m. Steam: One student is needed to travel through the process from A-J.

4. Have the students label from memory the major components of the reactors on the worksheets.

5. As review, have students complete the matching exercise. This may or may not be used as a quiz.

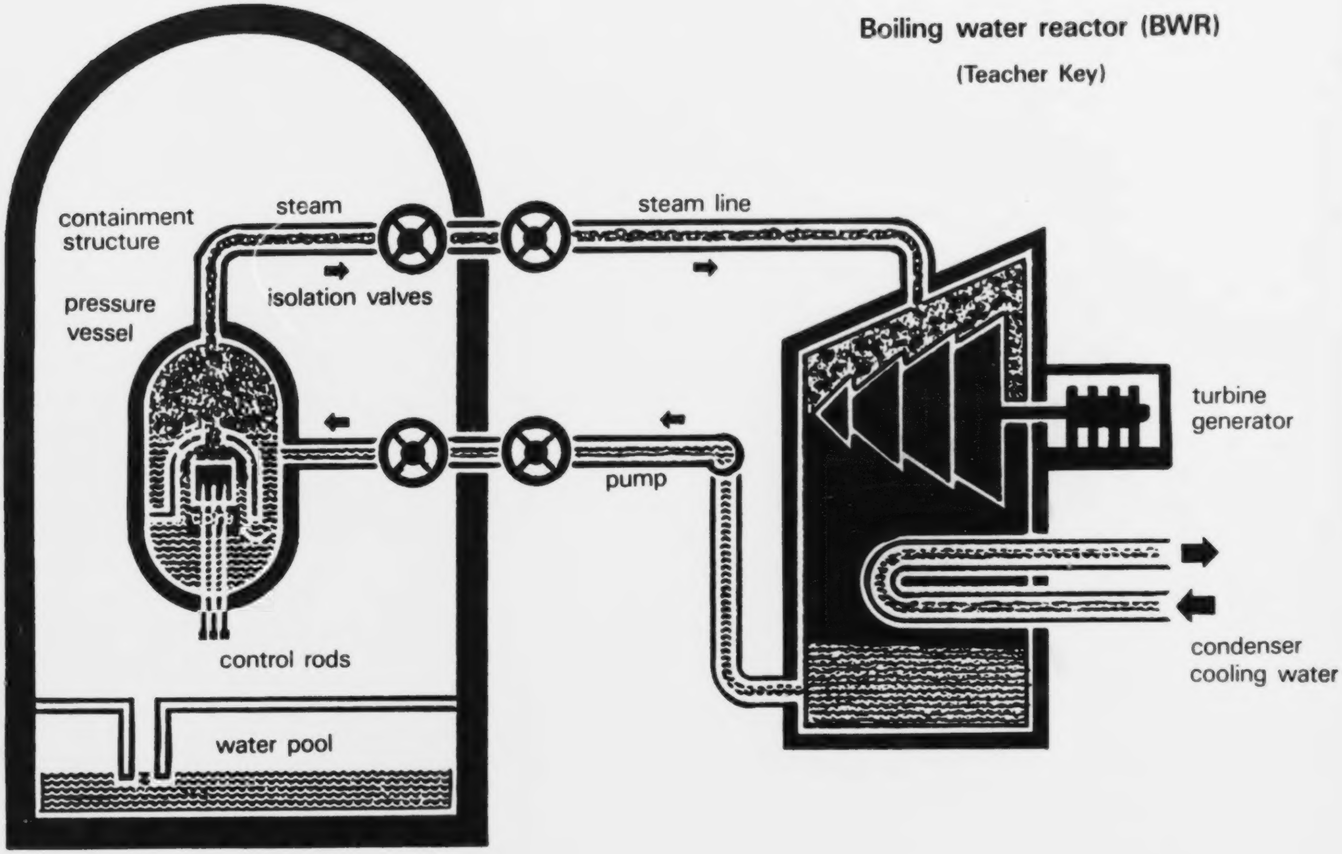
6. Follow with discussion.

Discussion

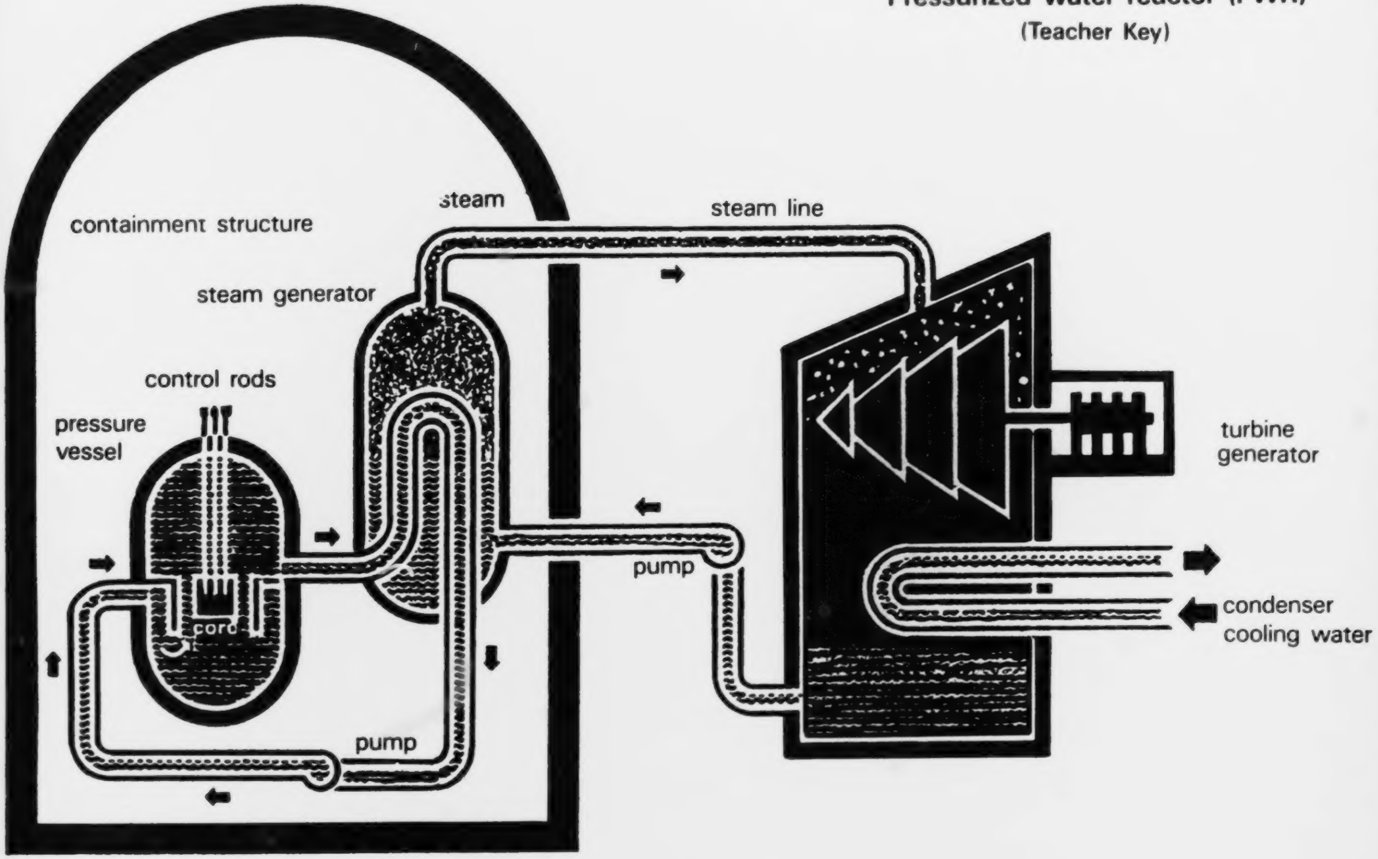
1. Compare the generation of electricity using fossil fuel, hydro power, or nuclear power.
2. What are some of the design features that contribute to the safety of nuclear generation? What happens in a nuclear accident?
3. As follow-up, a field trip to a nuclear power plant may be arranged. If this is not feasible, a person in a nuclear science profession could be asked to speak to the class.

Boiling water reactor (BWR)

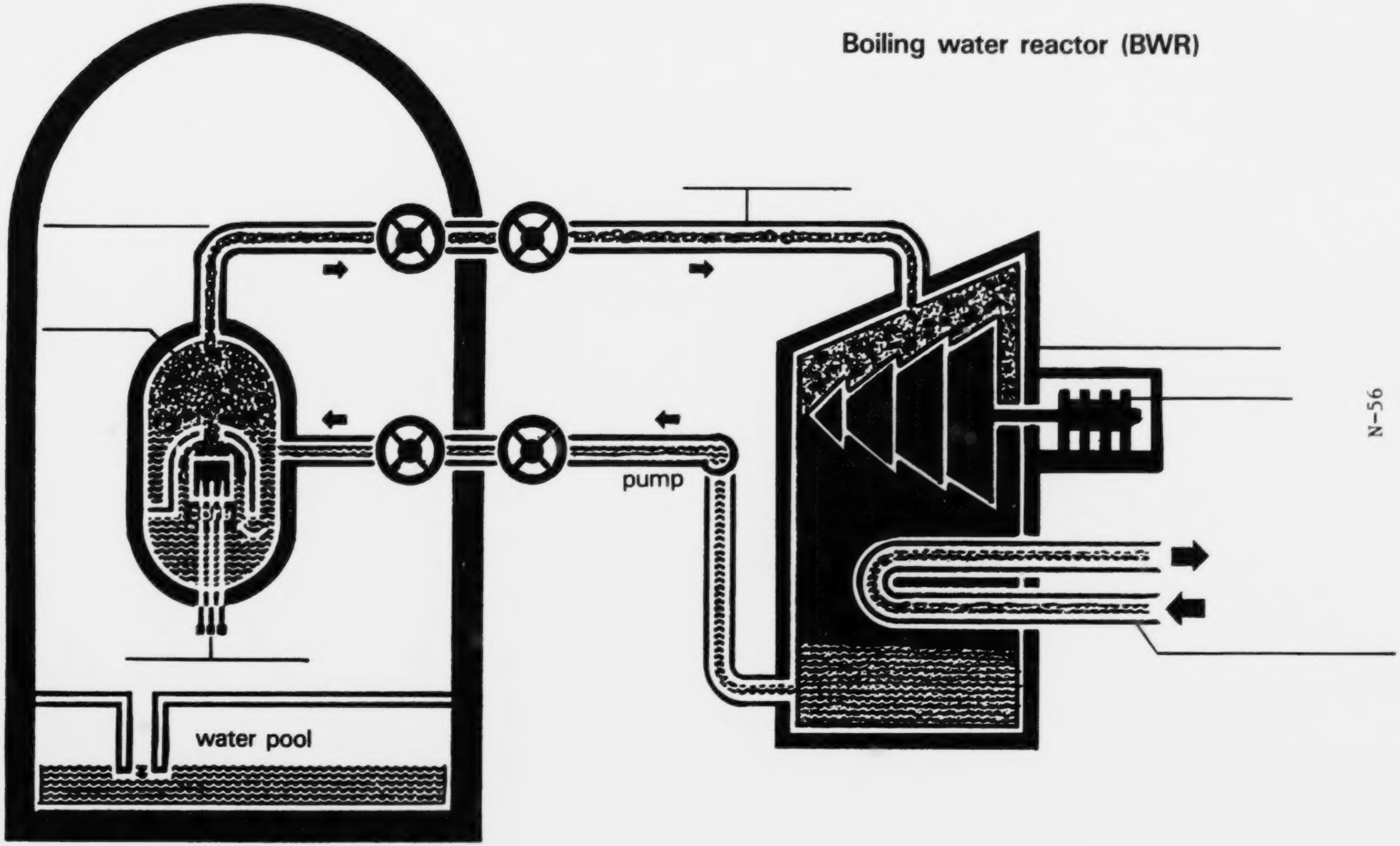
(Teacher Key)


containment structure
steam
isolation valves
steam line
pressure vessel
turbine generator
pump
condenser cooling water
control rods
water pool

Pressurized water reactor (PWR)
(Teacher Key)


steam
containment structure
steam line
steam generator
control rods
pressure vessel
turbine generator
core
pump
pump
condenser cooling water

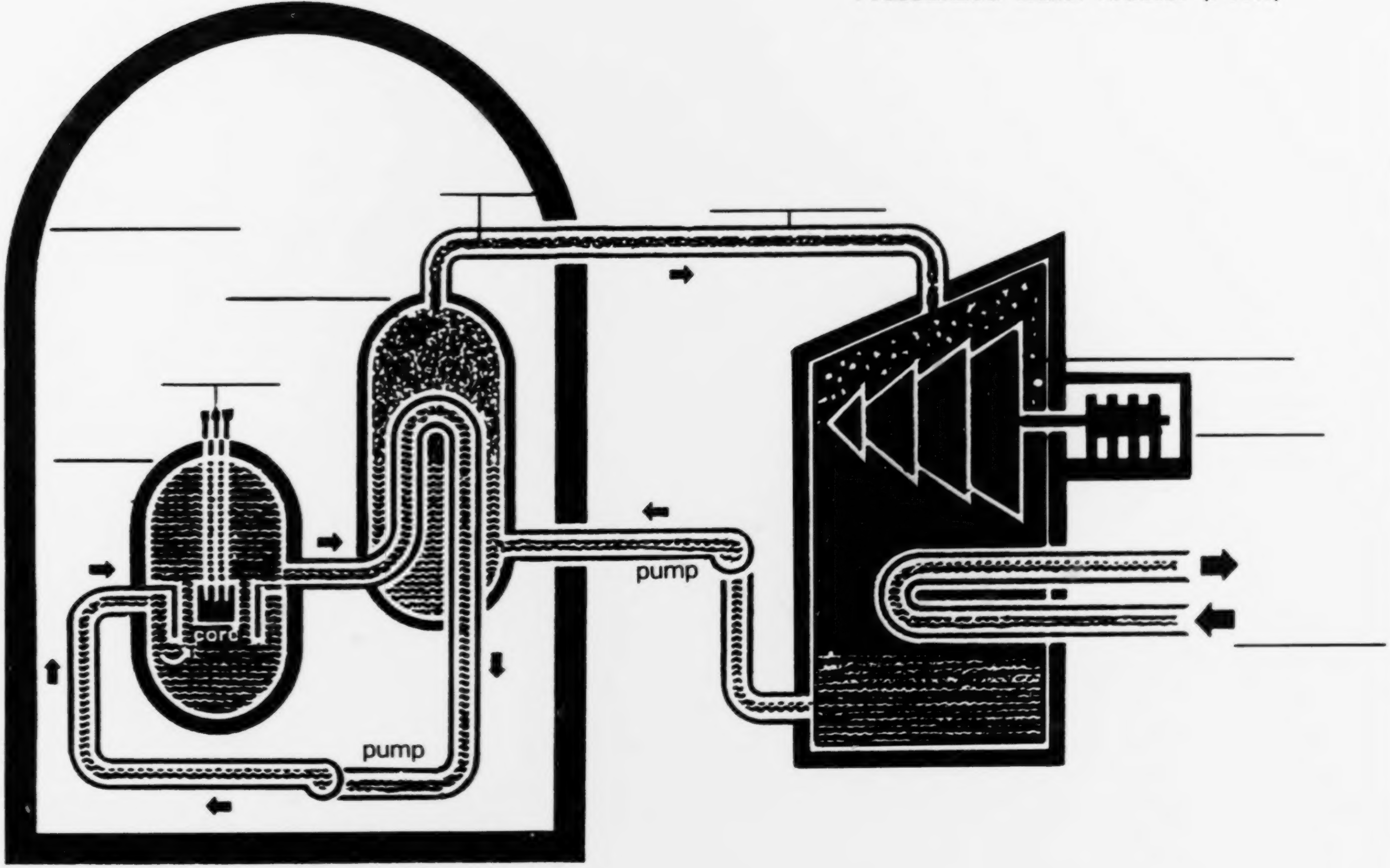
Boiling water reactor (BWR)


pump
water pool

N-56

322

Pressurized water reactor (PWR)


core
pump
pump

WORKSHEET

POWER PLANT CYCLE
Matching Exercise

1. Contains the fuel pellets inside the reactor vessel. ________

2. Causes the generator to create alternating current. _______

3. Moves rapidly inside the generator. ________

4. A heat exchanger. _______

5. Controls the chain reaction. ________

6. The containment vessel where heat is created by the splitting of atoms. ________

7. Electricity flows through before distribution. ______

8. Stationary inside the generator that helps create alternating current. _______

9. Houses the stator and rotor coils producing electricity. _______

A. Reactor
B. Fuel rods
C. Control rods
D. Steam generator
F. Generator
G. Rotor coils
H. Stator coils
I. Transformers

THE EFFECT OF RADIATION ON CHROMOSOME STRUCTURE

USE WITH:
Life Science
Biology
Advanced Biology

TIME:
3 class periods

MATERIALS:
(For each pair of of students
Irradiated seeds (e.g. those available Carolina Biological Supply Co.)
Acetoorcein solution
Coverslips
Slides
Razor blades
Watch glasses
Medicine dropper
Forceps
Filter paper
Test tubes with screws
70% ethyl alcohol
Compound microscope
Concentrated HCl
Carnoy's fixative with chloroform available through Carolina Biological Supply Co.
Petri dishes
Non-irradiated seeds
Worksheet (included)

Objectives

The student will:

1. Determine the effects of radiation on chromosome structure of germinating seeds.

Information

Preparation of "chromosome squashes" has become an important technique in modern genetics. For instance, it is now possible to predict before birth whether a child is a boy or a girl or to detect chromosomal disorders such as Down's Syndrome or Tay Sach's disease.

The structure of chromosomes in various stages of mitosis may be observed through a simple procedure known as a chromosome squash. This experiment involves chromosome squashes of the root tip of germinated seeds. Some of the seeds have been exposed to varying amounts of radiation, and others have received no radiation. The purpose of the experiment is to determine what effect radiation has on the chromosome structure. Irradiated seeds may be ordered from one of several research facilities or from commercial science material suppliers.

Procedure

1. Germinate both irradiated and non-irradiated seeds on moist filter paper in petri dishes, being careful to keep the two kinds of seeds separate and labeled.

2. Allow the roots to grow to a length of at least 3/4-inch. Clip the root with a razor blade, and immediately kill-fix it in a culture tube of 70 percent ethanol. Set up a culture tube for each kind of seed, and be sure to keep the seeds separate.

3. Allow the root tips to remain in the 70 percent ethanol for at least 24 hours.

4. After each root has been in the 70 percent alcohol 24 hours, pour a few milliliters of 95 percent ethanol and of HCl (equal amounts) into a watch glass. Pick roots that have been fixed in 70 percent ethanol and transfer them to the watch glass. Allow them to remain for 5 minutes. Be very careful with the acid. Take care to distinguish between the two roots.

5. Pour a few milliliters of Carnoy's fluid into a second watch glass, and transfer each root to this second watch glass for 3 minutes.

6. Transfer each root to the center of separate clean slides.

7. Using a razor blade, cut off each tip and discard the rest. Immediately add one or two drops of acetoorcein solution. Slice the tips into small pieces and allow these to remain for 5 minutes in the solution.

8. Place clean coverslips over the pieces of root, and tap lightly on the coverslips with the point of a pencil. Finally, press down with the thumb, being careful not to twist the coverslips.

9. Observe each slide under the microscope. Look for each stage of mitosis. Make a drawing of each stage of mitosis as seen on the slide of the normal seed. Do the same with what is seen on the slide of the irradiated seeds. Compare the drawings.

Discussion

1. What effects did the radiation seem to have on the chromosome structure of the irradiated seeds?

2. From the drawings, compare the effects of radiation on germinating seeds at each stage of mitosis. Are some stages more affected than others?

3. What are some useful applications of radiation in agriculture, medicine, industry, and materials development?

4. As follow-up, have a scientist or radiation technician visit the class and discuss and technologies for its use.

RADIOACTIVE DECAY

USE WITH:
General Science
Biology
Chemistry

TIME:
1 class period

MATERIALS: (groups of 4 students)
100 small objects such as dry corn, corn or pennies.
Shoe box
Graph paper
Worksheet (included)

Objectives

The student will:
1. Identify all "decay" products.
2. Graph data collected from experimental trials.
3. Make predictions about a different half-life.

Background Information

Radioactive minerals from the earth help geologists estimate the ages of the earth, of the remains of plants and animals, and of various artifacts. How are these estimates made? Geologic time clocks depend on Chemical elements that change by radioactive decay. These "clocks" are used to measure millions of years backward in time.

One method used to obtain a record of man's early history is through the decay of radioactive Carbon-14. For example, the Carbon-14 dating method dates the Dead Sea Scrolls as being approximately 2,000 years old.

Procedures

1. Place the small objects in a shoe box that has one side marked with an X.
2. Shake the box to represent some time period (5 or 10 shakes). The objects represent atoms of the parent element. Those which end up pointing at the X side of the box (after shaking) are to be considered daughter elements--those atoms that have decayed.
3. Set the box down and remove all of the "atoms" which have decayed. Count them and determine how many parent isotopes remain. Record the number here.
4. Shake the box again (5 or 10 shakes). Each shake of the box could represent many years of time. Set the box down and again remove the daughter elements. Record the number of parent elements remaining in the box.
5. Repeat this procedure at least four times.

6. Using graph paper, label the y-axis "number of parents remaining," and label the x-axis "number of years" (e.g., 5 shakes 1,000 years).

   Plot the information gathered in the previous steps.

7. From the graph, determine the following:

   a. Determine the half-life of the "isotope" by finding the point on the graph where half the objects remain. Then draw a vertical line down from the point to the year scale.

   b. A Different Half-life: Repeat the entire experiment but this time label both sides of the box with an X. Again plot the data on the graph. What do these two sets of results mean?

Discussion

1. For what purposes do scientists make use of radioactive time clocks?

2. What are some common uses of radioisotopes? What kind of radiation is emitted by each?

3. Discuss some problems presented by the long half-lives of some radioactive substances.

4. Discuss the importance of half-life to nuclear waste management.

Resource

Bioque, Pratt, and Thompson. Earth Science: Patterns in our Environment. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1975.

WHAT IS RADIATION?

USE WITH:
Physical Science
Biology
Physics
Earth Science

TIME:
1 class period

MATERIALS:
(Groups of 2-4 students)
Small transparent container with lid
Flat black paint
Blotter paper
Rubbing alcohol
Radioactive source (e.g., a lantern mantle)
Masking tape
Dry ice
Styrofoam square
Flashlight
Worksheet (included)

Objectives

The student will:
1. Define the three types of radiation.
2. Observe types of natural radiation.
3. Compute personal radiation dosages.

Background Information

The earth has always been radioactive. Everyone and everything that has ever lived has been exposed to radiation. Radiation is energy in the form of particles or rays given off by atoms as they change from an unstable to a stable state. Some radioactive atoms exist naturally; others are made artificially. During a normal lifetime, a human body may have more than 200 billion radioactive atoms. For example, about half of this natural radioactivity is Potassium-40. Potassium-40 makes up only 1/10 of 1 percent of all the body's potassium. Potassium is extremely important to brain and muscle function.

Radiation, both naturally-occurring and man-made, is frequently measured in rems. A roentgen equivalent mass (rem), the energy absorbed per gram of tissue, is a unit of radiation exposure. Radioactive elements release three main types of energy--alpha and beta particles and gamma radiation. Alpha radiation consists of positively charged particles traveling at roughly 10,000 miles per second. It is the least penetrating type of radiation and can be stopped by paper. Beta radiation is made up of electrons traveling at speeds of 100,000 miles per second. Beta particles can be easily stopped by a thin sheet of aluminum. The third type, gamma radiation, consists of waves of energy traveling at the speed of light. Gamma radiation is the most penetrating, and at least a foot of concrete would be needed to stop the rays.

Americans typically receive 100 to 200 millirems of radiation per year. In addition to background radiation, there is radiation exposure from X-rays, medical tests, nuclear and coal-fired power plants, smoke detectors, and color televisions, to name a few. Although no observable effects have ever been attributed to exposures below 50,000 millirems evenly distributed over a year's time, the government has established a limit of 500 millirems of radiation per year, not counting natural background radiation and radiation from medical testing.

Note To Teacher

Low-level radioative sources may be obtained from scientific supply companies.

Dry ice may be obtained from cold storage facilities or university laboratories or by using a CO2 fire extinguisher by holding the discharge opening near the floor and releasing the gas. Caution should be exercised in using dry ice.

Procedure

While radiation cannot be seen, a cloud chamber allows the tracks it leaves in a dense gas to be seen. Follow these steps to build a simple cloud chamber.

1. Paint the bottom of the container with black paint and let it dry.
2. Cut the blotter paper into a strip as wide as the height of the container. Cut two windows in the strip and place strip around the inside of the container.
3. Saturate the blotter paper in the chamber with enough alcohol so that it covers the bottom. (The blotter paper will absorb most of it.)
4. Place the lantern mantle in the container and seal the lid with tape.
5. Place the container on the dry ice for about five minutes to super-chill it. Darken the room. Shine the flashlight through the windows in the chamber while looking through the lid. Faint puffs and trails should be visible around the mantle. These are the footprints of radiation as it travels through the alcohol vapor. The vapor condenses as the radiation passes through. This is much like the vapor trail left by jets.

Discussion

1. Have the students try and identify these "footprints" using the following guidelines:

   Alpha - sharp tracks about 1 cm long
   Beta - thin tracks 3 cm to 10 cm long
   Gamma - faint twisting and spiraling tracks

2. To compute personal radiation doses, have each student complete the worksheet.

   a. Why are some higher than others?

   b. How much lower is each student radiation dose than the limit set by the government?

3. As follow-up, invite qualified resource persons to discuss radiation doses and their possible effects on human health.

WHAT IS RADIATION?

Compute Your Own Radiation Dose

We live in a radioactive world. Radiation is all about us and is part of our natural environment. By filling out this form, you will get an idea of the amount to which you are exposed every year. The average American is exposed to a total of 148 millirems.

	Yearly exposure in millirems
Cosmic radiation that reaches the earth:	44
Add 1 for every 100 feet above sea level: Pittsburgh is 1200 feet, so add 12 Denver is 5300 feet, so add 53 Atlanta is 1050 feet, so add 10 Chicago is 600 feet, so add 6 Coastal cities are at sea level so add 0	______
If your house is brick, add 45 stone, add 50 wood, add 35 concrete, add 45	______
Ground radiation (US average)	15
Water, food, and air radiation (US average)	25
Nuclear weapons testing fallout	4
If you've had a chest x-ray this year, add 9 for each one:	______
If you've had intestinal x-rays, add 210:	______
For each 1500 miles you've flown in a jet airplane during the year, add 1:	______
If you watch color TV, add 0.15 for each hour of average daily use:	______
If you live one mile from a nuclear power plant, add 0.02 for each hour you are typically home during the day:	______
If you live over 5 miles from a nuclear lant add 0:	______
TOTAL:	______

GLOSSARY

Alpha particles:	The nuclei of helium atoms, consisting of 2 protons and 2 neutrons.
Atom:	The smallest particle of an element that has all its chemical properties.
Atomic mass:	The mass of an atom relative to that of the isotope of carbon, $^{12}_{6}\text{C}$, which has the exact value of 12 atomic mass units.
Atomic mass unit (u):	A mass equal to 1/12 that of an atom of $^{12}_{6}$Carbon.
Atomic number (z):	The number of protons in the nucleus of an atom.
Beta rays:	Streams of fast-moving electrons ejected from radioactive nuclei.
Chain reaction:	A self-sustaining reaction which provides the energy necessary to continue the reaction.
Cloud chamber:	A device in which the paths of ionized particles appear as vapor trails.
Cosmic rays:	Very highly penetrating radiation from outer space.
Critical mass:	The minimum quantity of fissionable material that will sustain a chain reaction.
Cyclotron:	A particle accelerator that imparts very high velocities to charged subatomic particles.
Electron:	A particle of small mass having a negative electrical charge.
Electromagnetic waves:	Transverse waves moving at the speed of light.
Element:	Matter composed of atoms having the same atomic number and the same chemical properties.
Energy:	The ability to do work.
Fission:	The splitting of the nucleus of an atom

Force:	A push or pull that changes the motion of a body.
Fusion (nuclear):	The combining of nuclei of several light atoms to form a heavier nucleus with the release of energy.
Gamma rays:	Highly penetrating radiation emitted by the nuclei of radioactive atoms.
Geiger counter:	An instrument that detects radiation.
Half-life:	The time it takes for half of the atoms in a sample of a radioactive element to disintegrate.
Heat:	The internal energy of a body.
Internal energy:	The kinetic and potential energy associated with the molecules of a body.
Inverse proportion:	The relationship between two variables whose product is constant.
Ion:	An atom or group of atoms having an unbalanced electric charge.
Isotopes:	Different atoms of an element which have the same number of protons but different numbers of neutrons.
Kinetic energy:	The energy of motion of an object.
Law of Conservation of Mass and Energy:	The total quantity of mass and energy in the Universe remains constant.
Mass:	A property of matter that resists any change in a body's motion.
Mass-energy conversion:	The changing of mass into energy by the relationship E = mc2.
Mass Number:	The number of neutrons and protons in the nucleus of an atom.
Matter:	Objects having mass and volume.
Molecule:	The smallest particle of a substance that has all its chemical and physical properties.
Neutron:	An electrically neutral particle found in atomic nuclei and having about the same mass as a proton.

Nuclear energy:	Energy released during nuclear fission or fusion.
Nuclear reactor:	fission reaction produces energy and radioactive particles.
Potential energy:	The stored energy of a body as a function of its position relative to other bodies.
Power:	The rate of doing work.
Proton:	A positively charged particle found in all atomic nuclei and having a mass number of 1.
Radiation:	The transfer of energy by electromagnetic waves.
Radioactivity:	The emission of alpha or beta particles or gamma rays as a result of the disintegration of an atomic nuclei.
Radioisotope:	An isotope that is radioactive.
Rem:	The roentgen equivalent of mass (rem) is a unit of radiation expressed in terms of energy absorbed per gram of tissue and including the different types of radiation and their effects on man.
Transmutation:	The conversion of an atomic nucleus of one element into that of another.
Work:	The product of a force and the distance over which it acts.
X-rays:	A range of deeply penetrating electromagnetic radiation.

REFERENCES

American Nuclear Society. The Atom - A Closer Look. (Film.) LaGrange, IL: ANS, n.d.

Anderson, W. The Useful Atom. New York: World Publishers, 1966.

Asimov, I. Inside the Atom. New York: Abelard-Schuman, 1966.

________. Worlds Within Worlds: The Story of Nuclear Energy. 3 vols. Washington, D. C.: U.S. Department of Energy, 1972.

Cato. "Letter from Washinton." National Review, 26 May 1978: 632.

Chester, M. Particles. New York: Macmillian Publishing Company, 1978.

Clark, W. Energy for Survival: The Alternative to Extinction. Garden City, NY: Anchor Press, 1974.

Crull, J. L. "Tin Can Radiation Detector." The Science Teacher 53, (April 1986): 24-6.

Duderstadt, J. and C. Kikuchi. Nuclear Power: Technology on Trial. Ann Arbor: University of Michigan, 1979.

"Fading Dream of Cheap Atomic Power." U.S. News and World Report, 29 May 1978: 37.

Fermi, L. The Story of Atomic Energy. New York: Random House Books, 1961.

Freeman, S. D. "The Future of the Nuclear Option." Environment, September 1983: 12-6.

Groueff, S. Manhattan Project. Boston: Little, Brown and Company, 1967.

Hertsgaard, M. Nuclear Inc: The Men and Money Behind Nuclear Energy. New York: Pantheon Books, 1983.

Keenan, C. W. and J. H. Wood. General College Chemistry. New York: Harper and Row, 1966.

McKnown, R. The Fabulous Isotypes. N.p.: USA Holiday House, Inc., 1962.

Pringle, L. Nuclear Power: From Physics to Politics. New York: Macmillian Publishing Company, 1979.

Quagliano, J. and L. Vallarino. Chemistry. Englewood Cliffs, NJ: Prentice-Hall, 1969.

Raloff, J. "Nuclear Power at 25." Science News, 1 January 1983: 12-3.

Stoler, P. "The Irrational Fight Against Nuclear Power." Time, 25 September 1978: 71-2.

Weinberg, A. and I. Spiewak. "An Inherently Safe Reactor?" Scientific American, September 1984.

Wieseltier, L. "The Great Nuclear Debate." New Republic, 10 and 17 January 1983: 7-38.

Yost, D. "Safer Atomic Power." Omni, December 1984: 26.

Yulsman, T. "Birth Pains for a New Machine." Science Digest, July 1984.

Zuckerman, S. Nuclear Illusion and Reality. New York: Viking Press, 1982.

ALTERNATIVE ENERGY SOURCES

OVERVIEW

The instability and depletion of domestic oil sources and gas reserves, the possibility of political interruption of oil supplies, and increasing social and environmental concerns have led to a search for less expensive, more reliable, and less environmentally harmful domestic energy sources.

For purposes of our discussion here, all energy sources come from resources which can be classified as either renewable or nonrenewable. With proper management, renewable and nondepletable energy resources include the sun, wind, forests, and water. Nonrenewable and depletable energy resources include fossil fuels: coal, oil, and gas. Uranium, used to fuel nuclear power systems, is also depletable.

In 1974, 94 percent of all energy used in the United States was from nonrenewable resources, while only 6 percent was from renewable resources. During the years following, oil and gasoline prices escalated, and yet consumption of nonrenewable energy sources continued at a high rate. In 1983, 90.8 percent of the energy used in the United States was from nonrenewable sources--only a slight reduction from the 1974 figure!

There are a number of renewable energy resources being investigated as possible alternatives to traditional use of nonrenewable resources. Much attention has been given to energy derived directly from the sun--both active and passive systems. Although solar energy has good potential as an alternative source, it will not be included in this chapter. Alternative energy source possibilities in some areas of our country and in other countries are not viable options for the Tennessee River Valley region. The activities and discussions of this chapter will deal only with alternative energy sources which have application in the Tennessee Valley--biomass, wind, and other more decentralized alternatives, such as recycling waste or using energy from waste.

Biomass Energy

Biomass is a form of solar energy stored in a wide variety of plant and animal (organic) matter. The key process in the creation of biomass is photosynthesis. This process uses sunlight to convert carbon dioxide and water into higher energy products such as carbohydrates and proteins. Forest materials and residues, grains and other crops, animal manures, and aquatic plants are the principal sources of biomass. These raw materials can be converted into liquid or gaseous fuels and petroleum substitutes, as well as being used to produce heat, which converts water to steam, which drives a generator to produce electricity.

The sun is the oldest source of energy known. Biomass is the oldest source of fuel known. In the 20th century, fossil fuels replaced wood as the prime energy source, but interest in biomass never completely faded. In the early 1930s, the feasibility of converting grain to ethyl alcohol for use as a gasoline substitute was investigated.

During World War II, many nations worked to develop the fuel potential of trees. In Great Britain, cars operated on the gas produced from charcoal. Today, both private industry and government, including the Tennessee Valley Authority (TVA), are researching conversion methods and encouraging the application of available technologies. Currently, biomass supplies about 2 percent of U.S. energy consumption, primarily from the use of wood in the forest products industry and in home heating.

Energy from biomass is important in the Tennessee Valley because of extensive and well-located resources, important benefits, and only a few significant environmental problems. Major potential benefits include constructive use of wastes that otherwise contribute to pollution, the opportunity to improve forest productivity, and the displacement of more environmentally harmful energy sources.

Currently, some of the most popular biomass alternatives--wood for residential heating and alcohol from grains--have a potential for environmental damage. Large increases in wood stove use may lead to public health problems from particulate air pollution and fires resulting from improper installation and maintenance. The major dangers from using grain are erosion and ecosystem displacement caused by expanding crop acreage. However, if biomass resources and their conversion processes are managed properly, their use has potential for less environmental damage than the use of coal and synthetic fuels derived from coal.

In the Tennessee Valley region, wood is a major biomass resource. It serves as a fuel in the form of logs and residues (excess forest growth and insect-infested and diseased trees). Silvichemicals ("silvi" comes from a Latin word for "forest"), such as turpentine and resin, and carbon-based compounds made from lignin and cellulose are other energy-related wood derivatives. These materials serve as feedstocks for the production of a variety of chemicals such as methyl alcohol (wood alcohol or methanol) and other chemicals such as aldehydes, ketones, ethylene, and acids which can be used as petrochemical substitutes.

Nonwoody plants such as herbs and grasses have potential as cost-effective energy feedstocks. These plants have a high-yield capacity and can grow on marginal lands with minimal management.

Crops such as corn, wheat, sorghum, and sweet potatoes (sugar beets and sugar cane in other regions) are processed for their carbohydrate content to make ethanol (ethyl alcohol). Cellulosic materials found in herbaceous crops such as corn and rye can be converted to liquefaction to fuel oil.

Animal manure is a source of methane gas which can be manufactured by a process called anaerobic digestion (decomposition in the absence of oxygen). Methane can supply farmers with an alternative energy source associated with their crop and livestock production. This process can be viewed as completing a biomass energy cycle resulting in a higher degree of energy self-sufficiency for farming.

Elsewhere in the country, kelp and algae are potential aquatic sources of biomass. Through a process called biophotolysis, a blue-green algae produces hydrogen as a waste product. Kelp produces hydrogen gas through photoelectrolysis, a photochemical process.

Wind Energy

Wind results from the uneven heating of the earth and its atmosphere by vast amounts of energy from the sun. This fact allows for the classification of wind as a form of solar energy.

For centuries wind power has been used to perform mechanical tasks. However, widespread use of windmills in the United States began in the 1850s, primarily for pumping water. In the early 1900s, windmills were used to produce electricity on farms and in rural locations. In 1935, the creation of the Rural Electrification Administration (REA) brought a cheap, reliable, centrally produced source of electricity to the rural areas. At that time, windmills began to disappear as a source of electric power. However, with the dramatic increases in the cost of conventional energy sources in the early 1970s, wind was again considered as a possible economically feasible alternative.

In some regions of the country, such as the Plains States, sea coasts, and in some mountain passes, wind is a viable option as an alternative energy source. However, in the Valley region, its potential as a significant energy source is limited to a few locations where the wind is consistently strong enough to generate electricity. Where wind is a potential energy source, advantages of wind-powered energy systems over centralized fossil or nuclear systems include the facts that:

1. Wind is abundant and will last as long as the sun shines.

2. Wind is free. It is dispersed by nature and therefore does not have to be transported to a processing center. Onsite wind energy systems create power near the place where it is used, reducing the need for transmission and the resulting energy loss. Over the life of the operation, there are no fuel costs to consider, and maintenance costs can be very low.

3. Wind is powerful. Some mechanical methods of wind harnessing energy are long-proven technologies, particularly for pumping water in the Southwest Plains States.

4. Wind is clean. It powers various conversion equipment with no by-products to pollute the environment, except from the machinery needed to harness it.

5. Wind is an alternative. The energy for wind systems displaces imported fuels and increases self-sufficiency for the user.

Disadvantages to wind energy systems include:

1. Safety - High speed propellers present safety hazards to flying animals and, to a lesser degree, to people.

2. Constancy - Wind rarely blows constantly and with the same degree of power, thus requiring regular monitoring and regulation of the equipment. There is a small increase in the amount of noise pollution.

3. Economics - Initial investment in wind machinery and storage systems may be discouragingly high.

4. Storage - Energy from wind is not easily stored. Excess energy from wind is most frequently stored in batteries and in elevated tanks of water.

IS IT TOO LATE?

Objectives

The student will:

1. Analyze graphs of energy production and consumption.
2. Demonstrate an understanding of the relationship between production and consumption.
3. Estimate depletion rates for fossil fuels in the United States.
4. Demonstrate an understanding of the associations between "assumptions" and "predictions."
5. Infer from the analysis of graphs and data what sources of energy will be important in the year 2050.

USE WITH:
Social Studies
Mathematics
General Science
World Geography
Economics
History

TIME:
1-3 class
periods

MATERIALS:
Graphs
(included)

Background Information

Renewable energy sources are those not depleted by use if properly managed. Unlike coal, petroleum, and natural gas, renewable energy resources are quickly replaced. Examples of these resources are the sun, wind, falling water, and biomass.

According to some studies, the sun (solar energy) could supply from 3.9 percent to 4.5 percent of the United States' energy needs. However, by the year 2000, only about 1 percent of solar energy will be captured by using a solar cell. Other methods of using solar energy will need to be employed.

Wind power could be harnessed in parts of the United States, such as in the Plains States, and provide from 2 percent to 5 percent of the United States' energy needed in the year 2000.

Hydropower, energy available from falling or running water, could supply another 4.8 percent to 5.5 percent of the United States' needed energy by the year 2000.

Biomass is energy stored in the form of growing things like trees and plants. It is an energy source with great potential for the United States. Burning biomass, such as wood, waste, etc., generates heat. Decomposing biomass produces methane (a burnable gas that can generate heat). Biomass can be converted into alcohol (a liquid fuel). Biomass could supply 7.8 percent to 13.5 percent of our energy needs by the year 2000.

Producing or converting energy at the location at which it will be consumed is efficient and appropriate technology. For example, small digesters, used to convert organic waste to methane, could be located on farms, in homes, or at an industrial complex to provide fuel at these sites. Similarly, home solar collectors can be used to heat water inexpensively.

Appropriate technology, together with development of alternative, low-cost energy production, is essential if the United States is to become energy self-sufficient by the year 2000.

Procedure

1. Tell students that, in research, published information is not always in a form that is the most useful nor the easiest to make comparisons with. Earlier data are frequently presented in different forms from current data. However, to make projections, it is necessary to use data published in the past as well as currently.

2. Provide each student with a copy of published research from the past, "FIGURE I: ENERGY OUTLOOK, 1977." As an introduction, ask students to examine FIGURE I and answer the questions on the handout. Review the following questions with students:

   a. Of the energy sources listed, which are nonrenewable?

      Coal, oil, gas.

   b. In 1977, most of the energy we consumed was from what energy source? Is this a renewable energy source?

      Oil. No.

   c. According to the "ENERGY OUTLOOK" published in 1977, what percentage of the consumption pattern is provided by "wood and other sources?" Is wood a renewable energy source? Why?

      2%. Yes. We can grow more trees for harvesting.

3. Ask students to examine "FIGURE II: U.S. ENERGY CONSUMPTION, 1983," and compare the earlier data (1977) with more recent data (1983) by discussing the following questions:

   a. How do consumption figures in 1977 compare with 1983 consumption data?

      More of the consumption is for "other" sources--hydro and wood--and less for the hydrocarbons.

   b. In "FIGURE I, ENERGY OUTLOOK, 1977" why are "hydro" and "other" energy sources (including wood) omitted from circle graph "A. Energy Resources"?

      Because hydro and other sources such as wood are considered to be renewable resources.

   c. Looking at the consumption graphs for 1977 and 1983, which of the fossil fuels (hydrocarbons) was being used the most in each year?

      Oil.

d. How does the annual consumption rate of oil compare with that of gas for 1977?

The consumption rate for oil is much higher (almost twice as much).

e. How does the annual consumption rate of oil compare with that for gas in 1977 and in 1983?

The consumption rate for oil is much higher (almost twice as much).

OIL	GAS	DIFFERENCE	PERCENTAGE
1977			
1983			

f. Has our consumption pattern of oil and gas for 1983 changed from that of 1977? Explain.

4. Discuss with students the terms "production" and "reserves" as applied to fossil fuel based upon the following paragraph:

When referring to fossil fuel, industrialists apply the term "production" to indicate the amount of fuel made available for use each year. The term "reserves," as applied to fuel, would indicate how much of that energy source exists and could be made available using current technology.

Explain that paragraph.

Give each student a copy of "FIGURE III: PETROLEUM, COAL, AND NATURAL GAS: PROVEN RESERVES AND PRODUCTION." Explain to students that to estimate how long a given fuel supply will last, divide the "reserves" of the resource by its "production" for the same year.

Work this example on the chalkboard:

ESTIMATE FOR COAL SUPPLY DEPLETION

478.7 billion short tons* (U.S. proven reserve in 1984) = years of
fuel .82 billion short tons per year (U.S. production in 1984)
supply remaining.

The length of time before the United States runs out of coal = 583.8 years (using 1984 data).

Assumptions:
1. Coal continues to be used at the 1984 rate.
2. No more coal is discovered in the United States.
3. No new technology is developed to allow production of reserves currently unavailable.

*2000# American measurement (long ton is 2,240# metric measurement)

5. Have students use the information in Tables 1 and 2 of "FIGURE III: PROVEN RESERVES AND PRODUCTION" to estimate:

   a. the earliest date that the United States could run out of natural gas, according to 1984 data (answer: 8.36 years).

   b. the earliest date that the United States could run out of oil, according to 1984 data (answer: 8.77 years).

6. Tell students that the calculations they made in procedures No. 5.a. and No. 5.b. are good predictions, but the predictions are subject to limitations. Ask them what assumptions must exist for their predictions to be true.

   The fuels must be used at the same rate as in 1984, no new reserves will be discovered, and no new technology will be developed to increase availability of resources.

7. Ask students to assume that (a) we continue to use coal, petroleum, and natural gas at the 1984 rate; (b) new technologies are not developed; and (c) new sources of reserves are not discovered. Which fuel will be depleted first? Last?

   Natural gas. Coal.

8. Have students examine the information from procedure No. 5 and the circle graphs for "FIGURE I: THE ENERGY OUTLOOK - 1977" and answer the following questions: Which fuel loss will have the biggest impact on the United States when the resource is gone? Based upon your calculation, approximately what is the earliest date this might happen?

   Oil.

   According to this calculation, the supply of United States oil may be exhausted before 1993 unless (a) new fields are discovered in the United States, (b) new technology is developed to allow production of reserves currently unavailable, or (c) we reduce our rate of consumption by using alternative energy sources.

9. Place on the board the dates estimated by the students for No. 5. and No. 8. Then discuss with the class the nature of these predictions, which are based upon uncertainties regarding future events, including how we use fuels.

10. Discuss what happens when:

    a. Something becomes "rare" or "harder to find."

       - What happens to the price of that thing?

       - Could this happen to our nonrenewable energy sources?

b. Oil and gas become rare and harder to find.

- Will people be willing to pay more in order to have these resources to use as fuels?

- Will people be willing to pay more for new technology, new explorations for these resources, or more imports?

- Will people use more coal? If yes, how will this affect our coal reserves?

11. Have students compare "FIGURE I: ENERGY OUTLOOK - 1977" data with that presented in the circle chart of "FIGURE II: U.S. ENERGY CONSUMPTION, 1983." Have students answer the following question:

What energy source(s) appear in 1983 that was (were) absent from the "ENERGY OUTLOOK" in 1977?

Wood.

12. Have students examine "FIGURE IV: CONSUMPTION OF ENERGY SOURCE 1949-1984" and answer these questions:

a. What energy source had the greatest change in pattern of use? Was this an increase or decrease in use?

Oil is more noticeable; its use shows an increase of approximately 17 quadrillion Btus between 1949 and 1984. Nuclear did not even exist on the chart before 1970.

b. What sources had a higher consumption in 1983 compared to 1977?

Coal, nuclear, hydro, geothermal, and other.

c. Which energy sources in "FIGURE II: ENERGY CONSUMPTION, 1983" are renewable? Nonrenewable?

Renewable: wood, hydro. Nonrenewable: petroleum, natural gas, coal, nuclear.

13. Have students examine data for the four-year period 1980-1983 in "FIGURE V: U.S. WOOD ENERGY CONSUMPTION BY REGION" and ask them: In which region has there been:

a. The greatest increase in use of wood?

b. The greatest percentage increase in use of wood?

$$\frac{\text{1983 data - 1980 data}}{\text{1980 data}} \times 100 = \text{percentage increase}$$

14. Have students examine the data below, the circle graphs, and the calculations they made for procedures No. 5.a and No. 5.b. Ask students:

SOURCES OF RENEWABLE ENERGY

Possible Percentage of U.S. Energy Supply
for year 2000

Source	Lowest	Highest
Solar	3.9%	4.5%
Wind	2.0%	5.0%
Hydropower	4.8%	5.5%
Biomass	7.8%	13.5%

a. What percentage of the United States' energy needs would be depleted by the year 2000, based upon the data provided?

Oil 47 percent and natural gas 27 percent. Total 74 percent.

b. According to the data supplied, can renewable energy sources make up for depleted energy sources? If yes, how? If no, what is the shortage predicted by these data?

No. Maximum shortage is 55.5 percent, minimum shortage is 45.5 percent.

c. What assumptions were used in the previous prediction? (Hint: See No. 6.)

Each energy source is used at same rate, no new sources or reserves are discovered, and no new technology is developed.

d. Examine energy consumption in "FIGURE II: ENERGY CONSUMPTION, 1983" and "FIGURE I: ENERGY OUTLOOK - 1977." Are more alternative energy sources (other than hydrocarbons) used in 1983 than in 1977?

Yes.

e. What do you predict will happen to the energy use pattern of fuels as the year 2000 approaches?

More alternative energy sources will be used.

f. What alternative energy sources appearing in "FIGURE II: ENERGY CONSUMPTION, 1983" are most abundant in the region of the United States in which you live?

Discussion

1. Use previous class discussion, examination of graphs, and calculations made to answer the question: What will be the most important energy sources for the United States in the year 2050? For the region where you live now?

2. Extension:

   a. Have students call the National Energy Information Center (DOE) at (202) 252-8800 to authenticate data in FIGURE III, Table 1.

   b. Have students develop a game to simulate our consumption of fossil fuels, water, biomass, etc., used in meeting our energy demands. Colored paper, used to represent supply of energy sources, is an inexpensive, readily available material.

      Factors to be considered for energy sources should include identification and relative amounts of available sources, and accessibility to these sources. E.g., coal could be represented by black slips of paper and is abundant. Blue could be used to represent natural gas, etc. Some slips of paper could be made visible but not accessible "until new technology is available," such as for oil shale. Other slips could be well hidden to represent undiscovered reserves.

      Factors to be considered for the simulation activity should include differences in the ease of using the sources and differences in the renewable/nonrenewable aspects of the sources. Questions to be considered might include:

      - Why are we using one source more than another?

      - Is accessibility the only reason?

      - How can we represent a breakthrough in technology allowing access to fuel sources that are unavailable to us now?

      - How can we simulate a renewable resource, such as biomass, that must be managed properly?

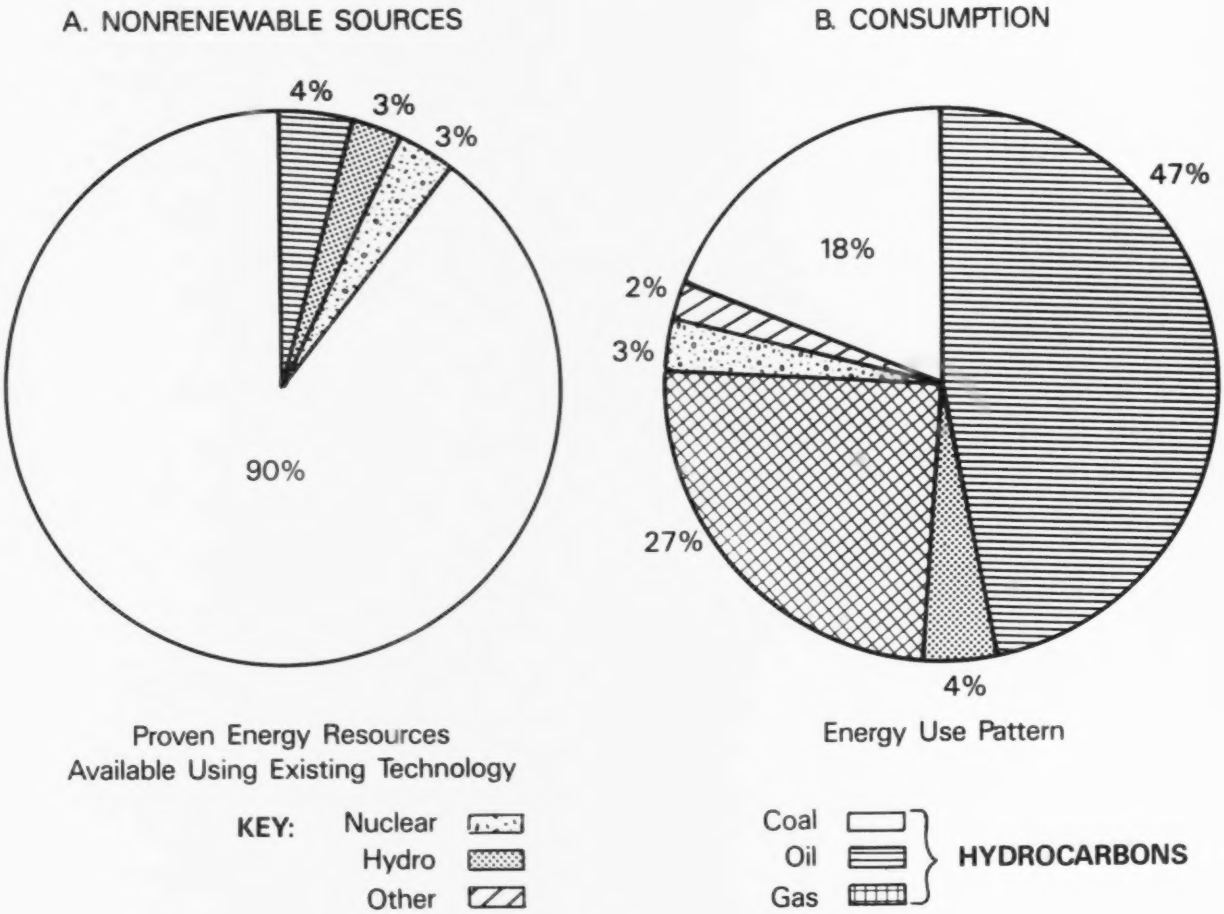
      - What do we do when a source is depleted?

   c. Ask students to write a brief report about the relative importance of fossil fuels and alternative energy sources, including appropriate technologies, in the year 2050.

"PRODUCTION" AND "RESERVES"

When referring to fossil fuel, industrialists apply the term "production" to indicate the amount of fuel made available for use each year. The term "reserves," as applied to fuel, would indicate how much of that energy source exists and could be made available using current

FIGURE I: ENERGY OUTLOOK—1977



A. NONRENEWABLE SOURCES

Proven Energy Resources
Available Using Existing Technology

B. CONSUMPTION

Energy Use Pattern

(Data from Federal Energy Administration,
Energy in Focus: Basic Data**, Washington, D.C., 1977.)**

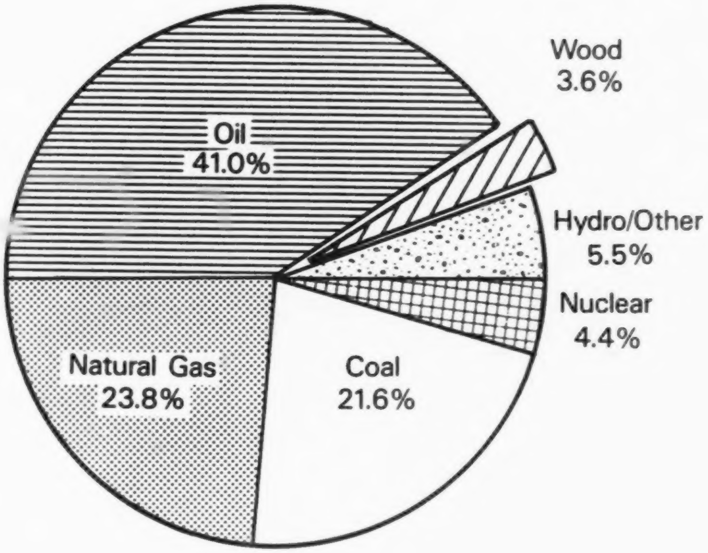
Examine the circle graphs above:

1. Most of the energy we consume is in the form of what energy source? ________________

2. What energy source is more abundant in terms of energy resources available using existing technology? ________________

3. According to the consumption pattern, what percentage is provided by wood and other sources? ____________

FIGURE II: U.S. ENERGY CONSUMPTION, 1983



Note: In *Estimates of U.S. Wood Energy Consumption, 1980-1983,* wood data was added to the primary energy total given in *Annual Energy Outlook 1983,* DOE/EIA-0383(83) (Washington, D.C., May 1984)

(Data from Energy Information Administration, *Monthly Energy Review*, Washington, DC., 1984)

Examine the circle graph above and "FIGURE I: ENERGY OUTLOOK - 1977."

1. How do figures in 1977 for hydrocarbon fuel sources (coal, oil, gas) compare with 1983 data?

2. In "FIGURE I: ENERGY OUTLOOK - 1977," why are "hydro" and "other" energy sources (including wood) omitted from circle graph, "A. NONRENEWABLE RESOURCES"?

3. Looking at the consumption graphs for 1977 and 1983, which of the fossil fuels (hydrocarbons) was being used most?

4. How does the annual consumption rate of oil compare with that of gas for 1977?

FIGURE III:
PETROLEUM, COAL, AND NATURAL GAS: PROVEN RESERVES AND PRODUCTION

TABLE I: Petroleum, Coal, and Natural Gas Proven Reserves**

RESOURCE	AS OF 1/1/80	AS OF 1/1/81	AS OF 1/1/82	AS OF 1/1/84	U.S. SUPPLY RUNS OUT IN * YEARS	(AT CURRENT RATE)
Petroleum (in billion barrels)						
U.S.	29.8	29.8	29.4	28.4		
WORLD	641.6	648.5	670.3	700.1		
Coal (in billion short tons)						
U.S.	472.7	Not Available	Not Available	478.7		
WORLD	975.2	Not Available	Not Available	986.2		
Natural Gas (in trillion cubic feet)						
U.S.	201.0	199.0	201.7	145.3		
WORLD	2,573.2	2,638.5	2,915.0	3,401.8		

*To update these figures, call the National Energy Information Center (DOE) at (202) 252-8800

**U.S. (Domestic) figures from Annual Energy Review, 1982. World figures from International Energy Annual for 1979, 1980, and 1981. Both published by the Energy Information Administration, Department of Energy.

FIGURE III:
PETROLEUM, COAL, AND NATURAL GAS: PROVEN RESERVES AND PRODUCTION

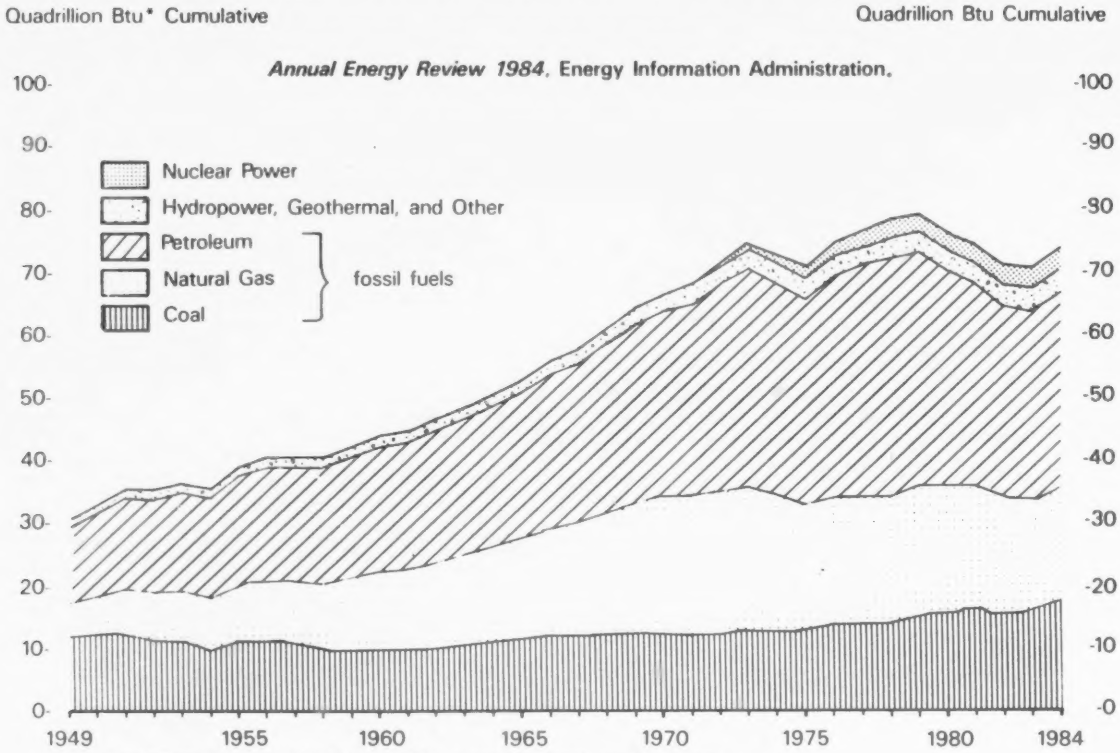
TABLE II: U.S. (Domestic) Production of Petroleum, Coal, and Natural Gases***

RESOURCE	1978	1979	1980	1981	1982	1984	OUT IN * YEARS	(AT CURRENT RATE)
PETROLEUM								
Million barrels per day	8.71	8.55	8.60	8.57	8.67	8.88		
Billion barrels per year	3.18	3.12	3.14	3.13	3.16	3.24		
COAL								
Billion short tons per year	.67	.78	.83	.82	.83	.82		
NATURAL GAS								
Billion cubic feet	19,974.0	20,471.0	20,379.0	20,178.0	18,462.0	17,392.00		
Trillion cubic feet	19.97	20.47	20.38	20.18	18.46	17.39		

***Figures from Monthly Energy Review, June 1983, published by Energy Information Administration, Department of Energy.

AE-16

FIGURE IV:
CONSUMPTION OF ENERGY BY SOURCE, 1949–1984



Annual Energy Review 1984, Energy Information Administration.

*One quadrillion Btu is 10^{24} Btu. (10^{24} is one followed by 24 zeros.)

1. Compare the amount of petroleum consumed in 1975 with that consumed in 1984.
2. Compare the amount of energy provided by fossil fuel in 1975 with that for 1984.
3. Identify trends in energy consumption by source over the ten year period ending with 1984.

FIGURE V:

U.S. Wood Energy Consumption by Region, 1980-1983 (Trillion Btu)

	REGION				
Year	South	West	Northeast	North Central	Total
1980	1,380	388	386	329	2,483
1981	1,349	416	395	335	2,495
1982	1,392	385	358	343	2,478
1983	1,526	411	380	323	2,640

Note: Totals may not equal sum of components due to independent rounding.

Data from Estimate of U.S. Wood Energy Consumption, 1980-1983, Department of Energy, Washington, D.C.

Examine data above.

1. In which region has there been the greatest increase in use of wood?
2. In which region has there been the greatest percentage increase in use of wood?

WOOD FOR HEATING

Objectives

The student will:
1. Use data from a table to plot a graph that compares wood types, density, and heat content.
2. Read a map to determine the types of they live.
3. Determine the best type of wood for heating a home or place of business.

USE WITH:
Mathematics
General Science
Physical Science

TIME:
1-2 class periods

MATERIALS:
Graph paper
Worksheets (included)

Background Information

People have used wood as a fuel for centuries. Because wood is a renewable resource, there is an increased use of wood today to conserve other resources that are nonrenewable. Fireplace efficiency (the percent of heat that actually is used for heating a room) has been increased in several ways. Wood stoves, safer and more efficient because of new technologies, have been added to homes and have become an important method of heating in the Tennessee Valley.

Wood is usually bought by the cord. A cord of wood is a stack of cut wood 4 feet wide by 4 feet high by 8 feet long. Selecting the kind of wood to buy is an important factor. Selection of wood affects the amount of heat that will be generated. Some woods provide a lot of energy; others much less. The burning rates, and the amounts of smoke and creosote produced, are also important factors in the selection.

Heat is measured in units: joules (joules), calories, Calories, Btus, or the kilowatt-hour. The joule is a unit of energy measurement in the International System. A calorie is the amount of heat needed to raise the temperature of one gram of water one Celsius degree. A Calorie (NOTE: Capital "C") is 1000 calories (or one kilocalorie) and is used when investigating food and diets. The Btu (British thermal unit) is the amount of heat needed to raise the temperature of one pound of water one Fahrenheit degree. Other relationships are shown in the following table:

One joule = 0.239 calories
0.000948 Btus

One calorie = 4.8 joules
0.00397 Btus

One Btu = 252 calories
1055 joules
0.000192 kilowatthour

One kilowatt-hour = 860,000 cal
3,600,000 joules
3,410 Btus

Procedure

1. Working in groups of three or four, have students use the data from "Table I: ENERGY COMPARISONS" to plot graphs that show the relationships between wood density (x-axis) and energy produced in Btu's per cord (y-axis). (Some students may help in determining the numerical ranges for the axes.)

   a. Students may use one or two letters to represent the type of wood as they graph the information in TABLE 1. Each group of students decides which type of graph it will make to chart the data (broken line, bar, etc.). Each student is to make his/her own graph, working within the individual group. (Students may need guidance.)

   b. Based upon the graphs, what kind of relationship exists between energy produced and wood density? Conclusions should be drawn within the group and then shared as a class.

2. Working in the same small groups, have students use the information presented in TABLES I and II to decide the best types of wood to use in a fireplace or wood stove:

   a. List the characteristics of a good wood for a fireplace or wood stove.

   b. Examine the characteristics of different woods.

   c. Select 3 or 4 of the best woods and place them in order, starting with the best wood first. Use the chart "COMPARISON OF WOOD QUALITIES" to enter the characteristics of the woods selected to study.

   Example:

   Comparison of Wood Qualities

Quality	Type of Wood			
	Redwood	Cedar	Elm	Ash
Hardwood or Softwood	Soft	Soft	Hard	Hard
Density (Hi/Lo)				

3. Have students examine the "MAP: MAJOR FOREST TYPES."

   a. Where are trees located that provide the best woods for burning?

   b. Which of those trees are located in the Tennessee Valley?

   c. Which are available in your area?

Discussion

1. What kind of trees are most abundant in the region where you live?

2. Are these trees classified as hardwood or softwood?

3. Which of the most abundant trees growing in your region are the best for producing heat energy when burned? (Hint: examine your graphs again.)

4. If 1 kWh = 3,410 Btu's, and burning a cord of wood produces 30 million Btu's, how many kWh would be produced by burning a cord of wood?

   30,000,000 Btu's/cord of wood - 3,410 Btu's/kWh = 8,797,653.9 kWh/cord of wood.

5. Check your monthly electric bill and report the number of kWh of electricity used each month. How does this compare to the amount of energy released from burning a cord of wood? Is all of the energy that is released from burning wood in a stove used in heating the room? If not, what happens to the rest of it?

6. Extension:

   a. Which would take up more space--hardwood or softwood of the same weight? What methods have been devised to increase the efficiency of fireplaces? Which woods do you think would create sparks and greater noise?

   b. Creosote, which results from the burning of some woods, is a residue that condenses in the flue or chimney. It is more prevalent when:

      - there is less air for the fire,
      - smoke density is high,
      - temperature is lower,
      - wood is added to a fire, and
      - moisture content is high.

      Creosote buildup can cause a fire in the chimney. Which type(s) of wood create the most creosote?

Table 1

Energy Comparison:

Type of Wood and Energy Content*

Type of wood	Density (Approx.) g/cm3	lbs./ft3	Millions of Btu's per cord, average
Ash	0.58	36.0	24.8
Birch	0.62	38.6	26.5
Cedar**	0.35	22.0	17.1
Cherry	0.50	31.2	21.5
Elm	0.56	35.0	21.5
Fir**	0.45	27.8	21.5
Hickory	0.70	52.2	30.0
Honeylocust	0.66	41.6	29.6
Maple	0.55	34.3	23.6
Oak	0.68	41.9	27.5
Pine**	0.54	33.8	21.5
Redwood**	0.44	27.2	17.1
Walnut	0.56	35.1	2.36

*Numbers are approximate and vary with the species of trees.
**Softwood

Table II

Wood Quality Comparison: Type of Wood, Moisture Content, Smoke Content, and Splitting Ease

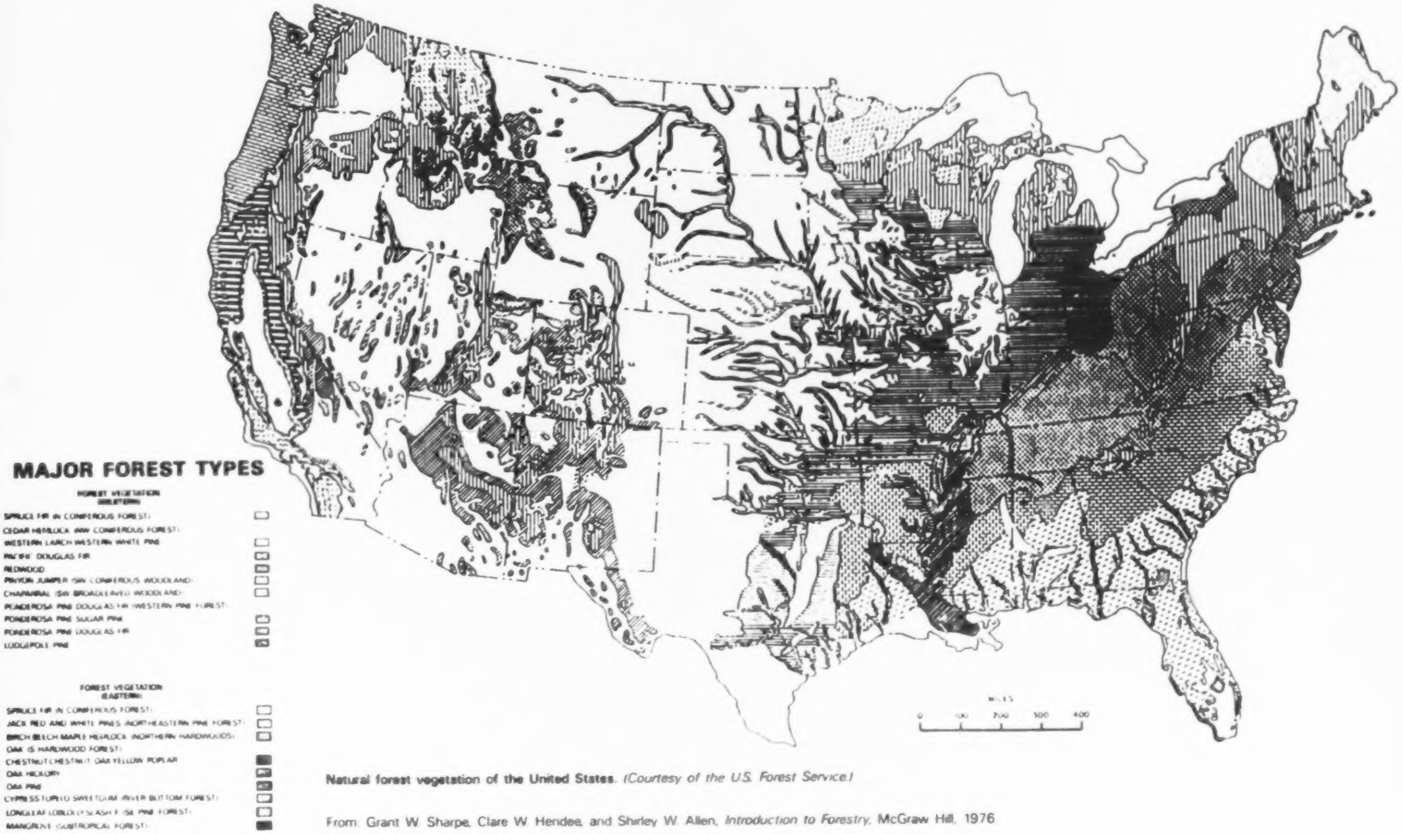
Type of Wood	Moisture Content	Pitch or Resin Content	Splits	Ignition	Burning Qualities	Smoke Content
Ash	Dry	Low	Well	Slow	Long lasting	Little
Birch	Medium	Low	Hard	Slow	Long lasting	Some
Cedar**	Dry	High*	Very well	Quick	Fast/hot	Some
Cherry	Dry	Low	Fair	Slow	Long lasting	Little
Elm	Wet	Low	Doesn't	Slow	Long lasting	Lots
Fir**	Dry	High*	Easy	Quick	Fast/hot	Some
Hickory	Medium	Low	Very well	Slow	Long lasting	Little
Honeylocust	Wet	High*	Very well	Quick	Fast/hot	Lots
Maple	Medium	Low	Fair	Slow	Long lasting	Some
Oak	Wet	Low	Fair	Slow	Slow	Little
Pine**	Dry	High*	Very well	Quick	Fast/hot	Lots
Redwood**	Dry	High*	Fair	Quick	Fast/hot	Medium
Walnut	Wet	Low	Fair	Slow	Long lasting	Little

*May cause creosote formation
**Softwood

CHART

COMPARISON OF WOOD QUALITIES

Qualities / Types of Wood	QUALITIES OF SELECTED WOODS			
Hardwood or Softwood				
Density (Hi/Lo)				
Moisture Content				
Pitch or Resin				
Splits				
Ignition (Quick/Slow)				
Burning Qualities (Slow/Fast)				
Smoke Content				
Availability				


MAJOR FOREST TYPES
FOREST VEGETATION (WESTERN)
SPRUCE FIR (N CONIFEROUS FOREST)
CEDAR HEMLOCK (NW CONIFEROUS FOREST)
WESTERN LARCH WESTERN WHITE PINE
PACIFIC DOUGLAS FIR
REDWOOD
PINYON JUNIPER (SW CONIFEROUS WOODLAND)
CHAPARRAL (SW BROADLEAVED WOODLAND)
PONDEROSA PINE DOUGLAS FIR (WESTERN PINE FOREST)
PONDEROSA PINE SUGAR PINE
PONDEROSA PINE DOUGLAS FIR
LODGEPOLE PINE
FOREST VEGETATION (EASTERN)
SPRUCE FIR (N CONIFEROUS FOREST)
JACK RED AND WHITE PINES (NORTHEASTERN PINE FOREST)
BIRCH BEECH MAPLE HEMLOCK (NORTHERN HARDWOODS)
OAK (S HARDWOOD FOREST)
CHESTNUT CHESTNUT OAK YELLOW POPLAR
OAK HICKORY
OAK PINE
CYPRESS TUPELO SWEETGUM (RIVER BOTTOM FOREST)
LONGLEAF LOBLOLLY SLASH F (SE PINE FOREST)
MANGROVE (SUBTROPICAL FOREST)
MILES
0
100
200
300
400

Natural forest vegetation of the United States. *(Courtesy of the U.S. Forest Service.)*

From: Grant W. Sharpe, Clare W. Hendee, and Shirley W. Allen, *Introduction to Forestry*, McGraw Hill, 1976.

POWER OF WOOD

USE WITH:
General Science
Mathematics
Chemistry
Physics
Environmental Science

TIME:
2-3 class periods

MATERIALS:
- Small beakers to hold 25 ml each (2)
- Thermometer
- Evaporating dish
- Small candle, at least 10, 15, or 20 grams
- Matches
- Ring stand and ring
- Graduated cylinder
- Balance
- Softwood shavings cedar or pine, 10, 15, or 20 grams (from woodworking shop teacher)
- Hardwood shavings 10, 15, or 20 grams
- Aluminum foil
- Worksheet (included)

Objectives

The student will:
1. Demonstrate knowledge of the heat available from two energy sources by burning wood and a petroleum product.
2. Compare the useful heat energy from burning wood to that from burning a petroleum product.

Background Information

Wood has been used as a source of energy for thousands of years. Over time it was found that fossil fuels provided a "clean," inexpensive energy for the generation of electricity. As a result, many people threw out their inefficient wood stoves and blocked up their drafty fireplaces. Then the energy crisis of the seventies resulted in higher oil prices and higher electric and heating fuel bills. People began looking for ways to lower these costs. More efficient, air-tight stoves and circulating fans in fireplaces have encouraged many people to return to wood for at least part of their source for home heating.

In the Tennessee Valley region, many small businesses are beginning to use wood as their only source of heat.

New technologies are expanding the use of wood. Waste wood from sawmills and lumbering operations can be made into pellets which burn in furnaces originally designed for coal. In an Oregon project, wood is being converted into oil at the ratio of 900 pounds of wood chips to one barrel of fuel oil. Wood is the original source of methanol (wood alcohol), and tree cellulose can be converted to ethanol by action of microorganisms. Both of these alcohols can be used as fuels as well as to replace chemical substances normally obtained from petrochemicals or fossil fuels.

Some advantages of using wood in the Tennessee Valley region are: (1) there is an abundance of trees, and wood does not have to be imported; (2) trees are renewable and scientists are researching methods to increase their growth rate and quality; (3) burning wood contains no sulfur to pollute the air and when properly burned, the ash content and carbon dioxide emission are low; and (4) the heat produced by burning wood is about the same as for burning an equivalent amount of coal.

All petroleum products are hydrocarbons. The physical state of the product (solid, liquid, or gas) depends upon the number of carbon atoms that it has in its structure.

1. Gases such as natural gas or propane have four carbon atoms or less.

2. Liquids such as gasoline or motor oil have from five to eighteen carbon atoms. Solids such as paraffin start at twenty carbon atoms and go higher. In this activity students will compare the energy (heat) produced by burning wood to that produced by burning a familiar petroleum derivative--paraffin. Students will compare wood shavings and paraffin as sources of heat energy.

Procedures

I. Burning a petroleum product and wood (SUGGESTED DEMONSTRATION).

   A. To measure the heat value of the paraffin:

      1. Measure 25 mL of tap water at room temperature and pour into a beaker.

      2. Insert a thermometer in the beaker of water and record the temperature of the water in degrees Celsius on the chart provided.

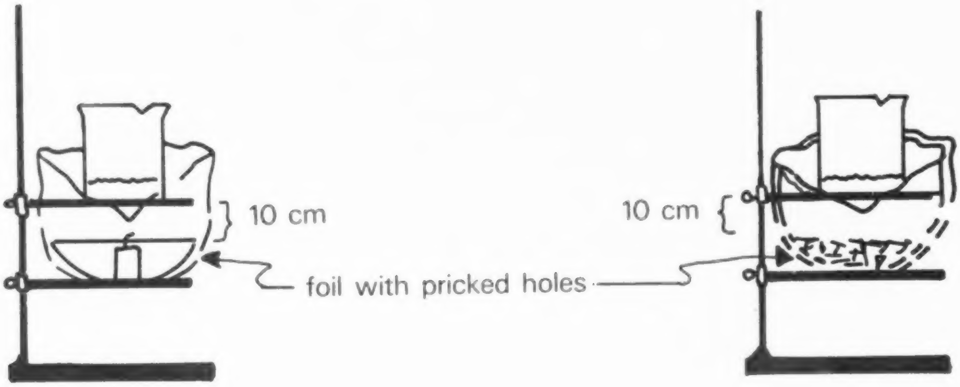
      3. Weigh the candle and trim off enough of it so that it weighs exactly 10, 15, or 20 grams. (Use a balance to weigh the candle.)

      4. Place the candle in an evaporating dish. Make sure the candle does not extend above the sides of the dish. Place aluminum foil under and around the dish and heater (as shown). Prick a few holes in the foil with a sharp pencil point.

5. Place the ring on the ring stand 10 cm above the dish and put a beaker containing 25 mL of water at room temperature on the ring. (Record on the chart the temperature of the water in degrees Celsius.)

6. Ignite the candle. Because the flame is farther and farther from the beaker as the candle burns, consider moving the candle up to maintain a constant distance from flame to beaker. Immediately after the candle has finished burning, have students record on the chart the temperature of the water in degrees Celsius and continue to record the temperature of the water until it starts to fall. Use the highest temperature recorded for the change in temperature of water. Ask students why they should use this procedure for recording the temperature change.

NOTE: You may want to burn the candle for a determined length of time (until about 2/3 of the candle is consumed) to accommodate the length of your class period. Weigh the candle again to determine the amount of candle that has burned. Determine the amount of heat given off per gram of candle.



B. To measure the heat produced from burning wood:

1. Measure 25 mL of tap water at room temperature and pour into a beaker.
2. Insert a thermometer in the beaker of water and record the temperature of the water in degrees Celsius on the chart provided.
3. Weigh out the same number of grams of softwood shavings (like cedar or pine) as grams used for candle. (Use a balance to weigh the shavings.)
4. Place the wood shavings in a dish fashioned from a double layer of aluminum foil. Use a sharp pencil point to prick holes in the side of the "dish." Allow sides of foil to extend above the bottom of the beaker (as shown).
5. Place the beaker of water on the ring stand 1 cm above the dish.
6. Ignite the wood shavings; immediately after they have burned, have students record the temperature of the water using the chart provided and continue to record the temperature as in No. A.6.

II. Comparing heat energy

By definition, the amount of heat required to raise the temperature of one gram of liquid water one Celsius degree is one calorie. If 50 mL of water at 20°C has 50 calories of heat added, its temperature will rise to 21°C. Note that at room temperature one mL of water has a mass very near to one gram. Ask students to:

A. Determine the change in temperature of the water heated by the burning of wood shavings. This temperature change (ΔT_W) times the amount of water in the beaker (25 mL) is equal to the number of calories of heat added to the water. To calculate how much heat was added to the water by burning the wood shavings, use the formula:

Hw Cal/ml C°	=	(T_2-T_1)	X	25 mL	X	1 Cal/ml-C°
calories of heat from paraffin	equals	temperature change	times	25 ml	times	one calorie per ml of water per degree Celsius

B. Determine the change in temperature of the water heated by the burning of wood, then calculate the amount of heat it added to the water.

C. Calculate the difference between the amount of heat added to the water by burning paraffin and wood.

Discussion

1. Which energy source appeared to produce the most heat?

The observed amount of heat produced will depend upon the amounts of heat captured when the wood and paraffin burned. Consider which burned faster and the amount of heat lost. Also see the Handbook of Chemistry and Physics for data.

For advanced students, data below can be used as a reference to discuss their findings and explore possible sources of experimental errors.

Heat of Combustion, Various Substances

	kcal/gram (avg.)
Butter	9.2
Charcoal	8.1
Animal fat	9.5
Gunpowder	0.73
Oak bark	4.5
Cotton seed oil	9.5
Lard (oil)	9.3
Paraffin (oil)	9.8
Crude oil	11.5
Rubber	3.4
Tallow	9.5
Woods:	
beech	4.2
birch	4.2
oak	4.0
pine	4.4

2. Was any heat lost, or did all of it go into heating the water?

Heat also raised the temperature of the evaporating dish, beaker, surrounding air, ring stand, etc.

3. Did each burning process lose the same amount of heat?

No. To prove the answer, the Handbook of Chemistry and Physics and other standard references can be used as a source of information.

4. Would it have made a difference if distilled water had been used? Why?

Probably not, since not all of the heat went into the water anyway. If salt water or water with impurities were used, the amount of heat gained by the water (per mL) would be different from that for distilled H_2O.

5. Which water would heat more quickly--clear water or muddy water? Why?

   Muddy water would absorb more heat by radiation.

6. Extension:

   a. Which wood would you use if you wanted a fire to burn quickly? Which wood would you use if you wanted a fire to burn slowly? Which wood is the most efficient for producing heat?

      Pine or cedar burns quickly while oak and hickory burn more slowly. Since rapid burning does not allow efficient heat transfer, slow burning is preferred.

   b. What difference in results would you expect if a different hydrocarbon were used?

      Coal and liquid fuels are hydrocarbons and have different burning rates and temperatures. For example, coal and fuel oil produce higher temperatures but do not burn so clearly as does a candle.

   c. Find out how many of the students in the class burn wood in their homes as part of their heating supply. What other types of heating fuels are used in their homes?

   d. Have students ask about the kinds of wood that they use at home. Students may want to bring in small samples and test for the amount of heat each kind gives off. (Woods other than those listed on the chart in the activity "WOOD FOR HEATING" are found and used in the Tennessee Valley; e.g., persimmon.)

   e. Use reference materials to find new ways we are using wood as a source of energy. Students might suggest wood alcohol as a product of wood that could be used as an energy source.

Resource

Hodgman, C. D., R. Weast and, S. M. Selby. Handbook of Chemistry and Physics. Cleveland: Chemical Rubber Publishing Company, n.d.

TEMPERATURE RECORD

	At time flame went out	After 1 min.	After 2 min.	After 3 min.
wood	______	______	______	______
paraffin	______	______	______	______

CHANGE IN TEMPERATURE

1. Wood:	2. Paraffin:
T_2 = C° (Water Temperature *After* Heating)	T_2 = C° (Water Temperature After Heating)
- (minus)	-(minus)
T_1 = C° (Water Temperature Before Heating)	T_1 = C° (Water Temperature Before Heating)
______________	______________
ΔTw = C° (Change of Water Temperature)	ΔTp = C°(Change of Water Temperature)

Heat added by burning wood:
Hw = ΔTw x 50 g x 1 cal/ml c°
Hp = ____C° x 25 mL x 1 cal/ml c°

Heat added by burning paraffin:
Hp = ΔTp x 50g x 1 cal/ml c°
Hp = ____C° x 25mL x 1 cal/ml c°

ALCOHOL AS AN ALTERNATIVE FUEL

Objectives

The student will:
1. Demonstrate knowledge of the process of converting biomass to alcohol.
2. Set up a fermentation process.
3. Compare the burning characteristics of alcohol to those of kerosene or other petroleum products.

USE WITH:
Chemistry
General Science

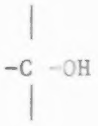
TIME:
3 class periods

MATERIALS:
(groups of 3 students
Bottle or other small top container
Molasses (20 mL)
Yeast (1/2 tsp.)
Cotton plug (for bottle)
(available in classroom)
Cardboard box
40-watt light bulb
Distillation apparatus
Evaporating dish
Matches
Kerosene
Distillation apparatus

Background Information

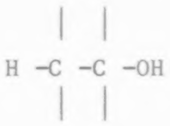
Alcohols are a group of compounds that consist of carbon, hydrogen, and oxygen. They can be used as clean, renewable fuels for cars and homes. The best known members of this group are methanol or wood alcohol (CH_3OH) and ethanol or grain alcohol (CH_3CH_2OH). Methanol is poisonous if taken internally but is widely used as dri-gas and windshield cleaner. Ethanol is used in alcoholic beverages and medicines. 2-Propanol (isopropyl alcohol) $CH_3CHOHCH_3$ is used as rubbing alcohol.

Methanol



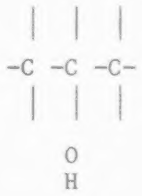
$-\overset{|}{\underset{|}{C}}-OH$

Ethanol



$H-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-OH$

2-Propanol



$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{\underset{OH}{|}}{C}}-\overset{|}{\underset{|}{C}}-$

Alcohols have long been used as fuels for cooking fondues, in campstoves, and in survival kits because of their clean burning and portable characteristics. Some alcohols are used as fuel for auto racing because they give superior performances in racing engines compared to racing engines using gasoline. Alcohol mixed with gasoline in a proportion of 10 percent ethanol to 90 percent gasoline can be burned in most automobiles without modification. This blend is called gasohol. (CAUTION: Damage to fuel line seals might be a problem; check automobile owner's manual.)

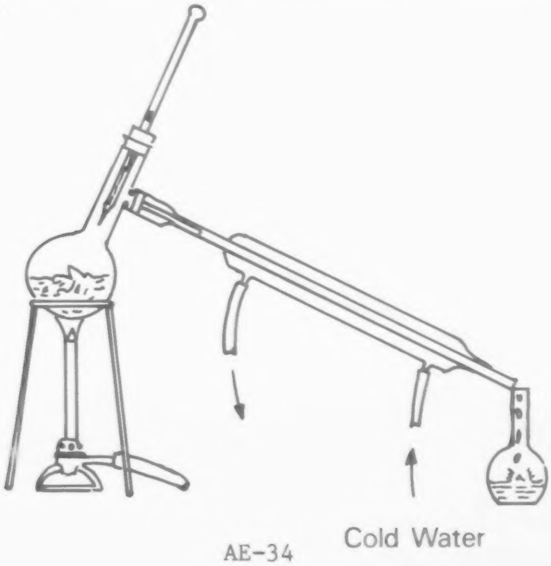
There are several reasons for considering alcohols as fuels. Biomass (material of organic origin) can be used to produce these alcohols, especially ethanol. Biomass is a renewable resource, whereas our rapidly vanishing petroleum resources are nonrenewable. Biomass resouces suitable for alcohol production are available within the United States, including the Tennessee Valley, and therefore could help reduce our dependency upon imported fuels. Technology for alcohol production from grains is well known and can be implemented easily.

Ethanol is produced from materials whose carbohydrate content can be fermented. Various grains, sugar crops, potatoes, and other starchy plants are commonly used to make ethanol. Fermentation of these products yields a very weak alcohol solution which needs to be distilled to a usable concentration. Adequate concentration is usually above 95 percent ethanol; however, since any grain contains both protein and carbohydrate, one bushel of corn (56 pounds) will produce 2.6 gallons of 100 percent (anhydrous) ethanol. There would also be 17 pounds of distilled dried grain (protein) produced which would be fed to livestock. Since molasses contains only carbohydrates, it is easily converted by fermentation into ethanol.

Procedure

Fermentation process:

1. To the bottle, add 20 mL of water and 20 mL of molasses.
2. Stir in 1/2 teaspoon of dry yeast.
3. Place a loose cotton plug in the top of the bottle and let ferment for 24 to 36 hours at about 90°F. A cardboard box with a 40-watt bulb turned on will provide adequate heat. CAUTION: KEEP BULB AWAY FROM CARDBOARD. (What occurs if the mixture stands longer than 36 hours?) Note: Carbon dioxide gas will be released slowly.
4. After 24 hours, assemble the distillation apparatus for the class (see diagram).



5. Combine students' samples for distillation process. Start heating and recording temperatures each minute, labeling the temperature at which the liquid starts to boil.

6. Continue to record temperatures each minute until 20 to 30 mL of clear liquid is collected; then remove heat.

The distillate:

1. Place the clear liquid (ethanol) that you have distilled in an evaporating dish and try to ignite it. If it burns, have students write a few sentences about the color of the flame, any odor, and residue or ash that remains.

2. Ignite kerosene or other petroleum product in the same manner as the distillate. Have students write down their observations about the burning kerosene. Which might make the best fuel--the distillate or the kerosene? Why? STUDENT CAUTION: Do not taste any chemical in the lab unless your teacher tells you to.

3. Demonstrate the miscability of alcohol and water; then ask: "What are the problems encountered in using alcohol as a fuel?"

Discussion

1. What kind of alcohol did the class produce? What other name is used for this liquid?

   Ethanol, grain alcohol, ethyl alcohol.

2. Did the alcohol give off any soot as it burned?

   No.

3. What products resulted from the burning of the alcohol? What is the chemical formula for methanol? What is the chemical formula for ethanol?

   Carbon dioxide and water result from burning alcohol. The formula for methanol in CH_3OH. The formula for ethanol is CH_3CH_2OH.

4. Did the kerosene burn as cleanly as the alcohol you produced? What undesirable product was produced from burning kerosene?

   No. Carbon or soot. Kerosene is used in jet engines. Smoke can be seen at take-off.

5. How many carbon atoms are in a molecule of ethanol? Methanol? How do these numbers compare with the number of carbon atoms in a compound like kerosene? What indication do you have that this is true from what you observed when alcohol and kerosene were burned?

   A molecule of ethanol has two carbon atoms. A molecule of methanol has one carbon atom. Kerosene has about ten times as many carbon atoms as does methanol or ethanol. Excess carbon "soot" is produced when kerosene is burned.

6. Examine the temperatures recorded.

   a. What was the highest temperature recorded during the distillation process?

   b. Is this the boiling point of alcohol? Water? A mixture of water and alcohol? Explain your answers.

   c. Compare the boiling point with that of kerosene and gasoline. Which would take the most energy to distill?

7. What does the word "organic" mean as used in chemistry? Such information is studied in the field of organic chemistry.

   Organic compounds are carbon-containing compounds.

8. Extension:

   a. Help students draw structural diagrams of various kinds of alcohol molecules that show how we think the atoms are connected in the molecule.

   b. Have students use candy corn, sweet potatoes or Irish potatoes, to produce alcohol and compare results.

   c. After examining labels on products in your home, list nonprescription drugs, food products (no alcoholic beverages), and other chemical products containing alcohol that you or your family use. Include product name, percentage of alcohol, and advertised use of product.

   d. If you live on a farm or in a farming community, list some of the crops that could be used to produce alcohol. If an alcohol-producing plant (distillery) is nearby, arrange for a visit and a tour of the facility for your class. What is one problem that you might have with the authorities if you tried to set up a still and produce your own alcohol for fuel?

   e. Use reference materials to find out why we are not using more alcohol fuels. What are the costs involved in production? Are there special properties of alcohol that might produce problems if mixed with gasoline in a ratio of 1:1?

BIOMASS ALTERNATIVES

USE WITH:
Chemistry
General Science
Physical Science
Biology

TIME:
4 class periods

MATERIALS:
(for the class room)
Wood shavings (or small pieces)
Distillation Apparatus
  distillation flask
  solid rubber stopper
  tubing
Large test tube
Manure (cow or sheep)
2-3 gallon bucket or can
Large plastic bag
Thermometer (4)
Pneumatic trough (4)
Gradulated cylinder (4)
Lettuce, cabbage, or grass
OPTIONAL:
Incubation chamber
Cooler with ice cubes (For each student)
Plastic bags (2): small, opaque, heavyduty
Closures for plastic bags
Masking tape
Grease pencil
Worksheet (included)

Objectives

The student will:

1. Examine the process involved in obtaining fuel from biomass.
2. Collect methane given off from plant and animal wastes.
3. Analyze factors which influence production of methane.

Background Information

Most of our nation's energy now comes from a finite supply of fossil fuels. These fuels include coal, oil, and natural gas.

Coal comprises about 20 percent of our energy source, is abundant, and has a reserve that should last for many years. However, burning coal creates significant environmental problems, including air pollution due to ash, acid rain, and other undesirable residues.

Oil provides almost 45 percent of our energy source. However, supplies are dwindling rapidly and the need to import oil presents many problems.

Natural gas provides about 25 percent of our energy and has many of the same problems as oil. Locating the undiscovered fossil fuel reserves, recovering them at an affordable cost, and then using them wisely without causing pollution is a major task.

There are alternatives to these fuels, however, and we must begin looking at these alternatives and their components. One alternative is the use of biomass (material of organic origin) for the production of energy. Three of these processes are (1) aerobic decomposition, (2) destructive distillation, and (3) anaerobic decomposition.

Aerobic decomposition of carbohydrate--rich plant material can produce ethyl alcohol (ethanol or grain alcohol). Alcohol is valuable as a hydrocarbon fuel replacement in the form of gasohol. NOTE: AEROBIC ALCOHOL PRODUCTION IS THE TOPIC OF ANOTHER ACTIVITY IN THIS VOLUME.

Destructive distillation of wood is accomplished by heating wood in the absence of air (oxygen). The products of this process are wood alcohol (methanol or methyl alcohol), acetic acid, acetone, turpentine, and charcoal. All of these products have important industrial value in their own right, but they are also considered to be important alternatives to similar products which come from hydrocarbons.

Wood is a renewable energy resource, thus providing an important alternative to products from our rapidly dwindling supply of fossil fuels, which are nonrenewable energy sources.

Anaerobic decomposition of plant and animal wastes, in the absence of oxygen, produces methane. Methane is composed of carbon and hydrogen and is the main component of natural gas.

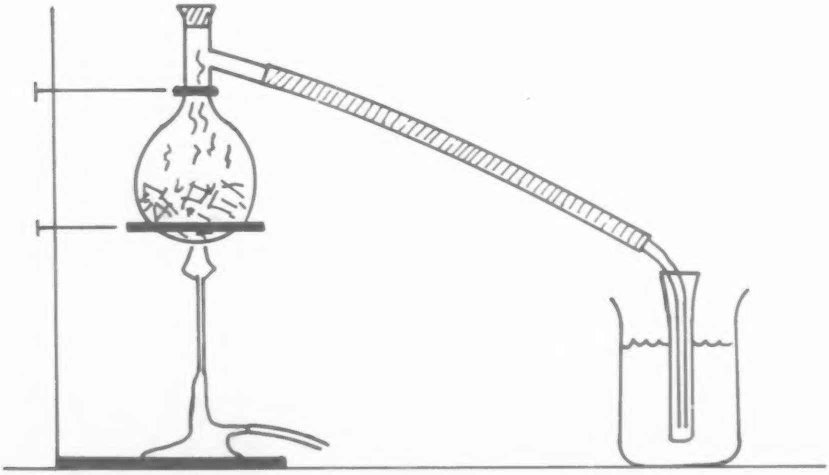
The primary purpose of this activity is for students to investigate and analyze the process of (1) destructive distillation of wood and (2) anaerobic decomposition of animal and plant wastes.

Procedure

I. Destructive distillation of wood (DEMONSTRATION).

A. SUGGESTION: Perform this demonstration after students have prepared their systems for production of methane and are waiting for results.

B. Give each student a copy of "LIQUID FROM BIOMASS." Using the apparatus shown here, students can observe the destructive distillation process. CAUTION: THE PRODUCTS COLLECTED IN THE TEST TUBE CONSIST OF ALCOHOL, TURPENTINE, ACETONE, AND ACETIC ACID. CARE SHOULD BE TAKEN NOT TO EXPOSE THEM TO A PERSON'S SKIN. The residue in the flask will be charcoal. The products collected in the test tube can be further distilled, using a distillation apparatus to separate the substances.



II. Anaerobic decomposition of plant and animal wastes.

A. Advanced preparation for the production of methane.

1. Two days in advance, obtain a supply of leaf lettuce, cabbage, or grass clippings in sufficient quantity to provide a large handful for each of your students in half of your class. The school cafeteria, the produce manager of a grocery store, or a vegetable market may be able to provide a supply at no cost. Cut or shred the material into small pieces, then crush it or bruise it to initiate spoilage. Spoilage can be further accelerated by mixing the vegetable matter with a small amount of garden soil and keeping it warm.

2. Obtain a supply of fresh (green) animal manure adequate to provide two cups for each of your students in the other half of your class. Fresh cow manure works best. It may contain small amounts of straw or hay without creating a problem. Avoid any sticks or other things that could punch a hole in a plastic bag. This material can best be handled by placing it within a container (such as a garbage bag) that can be securely closed and placed inside a lard can or bucket. The material should have enough water content so that it is highly viscous (semi-liquid). Local farms, a stock yard, or large animal treatment facility are sources of manure. Manure from a cow is preferred; sheep, horse, hog, or chicken manure is a satisfactory alternative. NOTE: Check with students to see if they have access to cow manure. Special arrangements may need to be made for bringing it to the classroom.

B. Preparing the system (bags filled with waste material).

1. Give each student a copy of "GAS FROM BIOMASS." Discuss with the students the general plan for this activity. Assign groups of four to work together. Let them decide which pair within the group will use vegetable material and which will use manure.

2. Caution the students about the need for care in handling the material and in preparing the bags for gas collection. Methane will escape if there are holes in the bags or if the bags are not carefully closed and secured. Use thick, opaque bags that will hold 2 to 3 gallons.

3. Bags should be tested for air leaks by inflating with air and submerging them in water prior to use, and they should be labeled. (Hint: Wax pencil-writing on masking tape makes a good label and is waterproof. Apply it before inflating and submerging bag in water to check bag for air leaks.)

C. Estimating the volume of material placed in the bags.

1. Fill a pneumatic trough with water until it overflows.

2. After water stops coming out of the trough,

   a. Place a container under the spout to catch the water that runs out when the bag is submerged.

   b. Submerge the bag of vegetable matter or manure and measure the amount of water that is caught in the container. The volume of the water displaced is the volume of the bag and contents.

D. Incubation period for systems.

1. Have students place their bags in various locations, recording the approximate temperatures there. (If incubators or warming chambers are available, use them and record temperatures.) Suggested locations:

   a. In an incubation chamber or under an inverted cardboard box with a 40-watt light bulb to supply heat.

   b. In the sunlight of a classroom window.

   c. In the shady part of the classroom, or in a portable cooler with a few ice cubes, replaced once each day as the ice melts.

2. Systems in the warmer environment may fill with gas in a few days and should be evaluated then. It is optional whether or not the other systems are evaluated at the same time. Systems in cooler environments will take much longer and may not generate methane at all, if temperature is sufficiently low. Have students make daily observations and record them for 5 to 10 days.

E. Findings and analysis.

1. Have students use the immersion method again, to find the volume of bag and contents. CAUTION: STUDENTS SHOULD HANDLE THE GAS-FILLED BAGS WITH CARE. Students record the volumes and complete the DATA RECORD portion of student sheets.

2. Place data (including amount of gas generated, volume of material used, etc.) on the chalkboard according to type of material used, locations of systems during incubation, and temperature of locations.

3. Discuss the observed differences. Relate the volume of gas generated to volume of initial waste used, the type of waste material, and the approximate temperature ranges at the locations of the system.

F. Testing the gas (DEMONSTRATION).

1. Assemble a pneumatic trough and a few water-filled gas-collecting bottles.

2. With the help of a student, submerge one gas-filled bag at the time and puncture a hole in the double plastic bags with a sharp instrument. Allow the gas to bubble into gas-collecting bottles.

3. After filling several bottles, test a few of them by bringing a long taper near the mouth.

4. For comparison, test other bottles filled with natural gas. Compare the clean burning nature of methane and natural gas by burning kerosene or other lower grade fuel.

G. Reaching Conclusions.

1. Some students may be somewhat disappointed with the amount of gas generated. If this is mentioned, point out that the anaerobic decaying process is very slow. Large amounts of decomposing plant and animal matter are needed to generate enough gas to be economically feasible for commercial purposes. Obtaining methane from the wastes of animals in large feedlots is an alternative energy source in some less technologically developed countries. The methane produced in these cases is used for domestic purposes (such as cooking, heating, etc.).

2. In the follow-up discussion, students may be led to point out that energy (in the form of heat) was needed to speed up the reaction. Ask students where this energy might come from. (Hint: Solar heating or burning some of the methane.) Which source would contribute most to the efficiency of the gas generating system?

3. Give each student a copy of "LIQUIDS AND GAS FROM BIOMASS: A SUMMARY."

Discussion

1. Did all of the systems in the class generate the same amount of gas? If not, what are some reasons for this?

   Temperature of location, kinds of waste, time.

2. Which kind of waste material generated the most gas? Was this true no matter where the system was placed in terms of temperatures? What variables seem to most affect the amount of gas generated?

3. In California, for many years, some communities have used deep gullies and valleys as waste dumps. The dumps are now covered with soil because the gullies are full. They have discussed the possibility of drilling wells into these old dumps to retrieve the natural gas. Ask students if they believe this might work? Would it work in a Canadian city? Ask them to explain their answer.

4. How does the process of destructive distillation of wood compare with anaerobic decomposition of plant and animal wastes? Consider:

   - heat energy involved
   - physical state of products
   - type of chemical products
   - usefulness of products
   - relative difficulty of carrying out the process under laboratory conditions

5. Have students discuss such things as the ease of handling of, and odors associated with, destructive distillation of wood and anaerobic decomposition of plant and animal wastes. What constraints do these factors place upon the location of a possible commercial installation which would use these processes?

6. Ask students to write a paragraph summerizing the answers to questions No. 4 and 5 with regard to use of biomass an alternative source.

GAS FROM BIOMASS

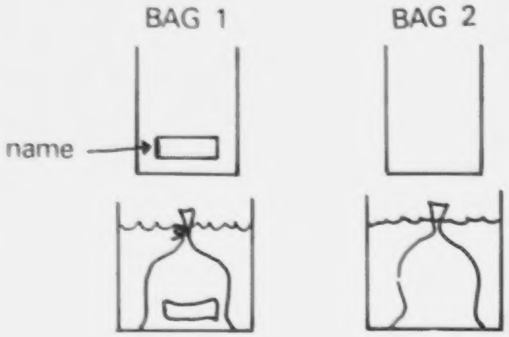
Introduction

When organic material, such as plant and animal waste, decomposes or breaks down without oxygen, gases are produced. In this activity, you will (1) look closely at the process of producing gas, (2) measure the gas produced, and (3) identify factors that affect production of the gas.

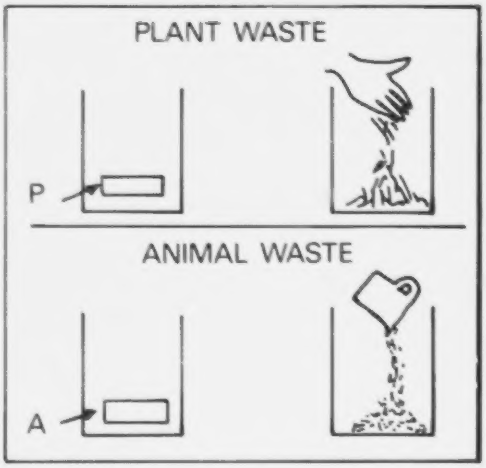
It is important to understand the processes of gas production because (1) the gas can be used as a fuel, and (2) if not properly controlled, gas produced from sewage--animal and plant waste--can be very harmful. Sometimes the gas can cause an explosion. When the gas is mixed properly with air, the mixture burns cleanly with a blue flame.

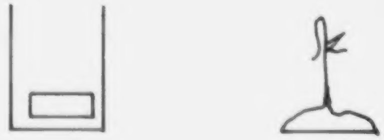
Procedure

1. Each person has two plastic bags.
    a. On one plastic bag (Bag 1), place a 3-inch strip of masking tape (according to the teacher's instructions). With a grease pencil, write your name on the left corner of the tape.
    b. Blow air into both bags. Close each bag tightly. Look closely for air leaks by placing the bags in water. Dry the bags. (Use only bags without leaks!)



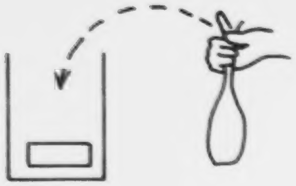
2. Work in groups of four students. One pair of students (P) will use PLANT waste. The other pair of students (A) will use ANIMAL waste.
    a. Students (P) place one large handful of PLANT waste in the plastic bag WITHOUT the label (Bag 2). On Bag 1, write "P" on the label as instructed.
    b. Students (A) place about two cups (0.5L) of ANIMAL waste in their Bag 2. On Bag 2 write "A" on the label. HANDLE ALL PLASTIC BAGS WITH CARE! DO NOT PRICK HOLES IN THEM.



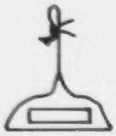


3. Squeeze out all of the air from Bag 2.

   a. Close the bag by twisting the top about 8 to 10 cm only. LEAVE ROOM FOR GAS TO INFLATE THE BAG.



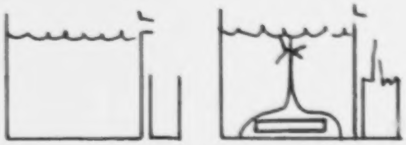
   b. Loop the twisted part of the bag over and tie it carefully. Let no air in or gas out!



4. Place Bag 2 (with waste) in Bag 1 (with the label).

   a. Remove all of the air.

   b. Close the bag as you did for Bag 1.



5. Estimate the volume of your double bag and its contents.

   a. Submerge the closed bag in water.

   b. Measure the water that has been displaced.

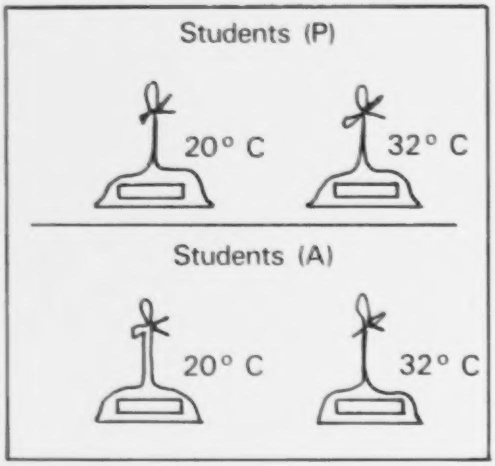
   c. Record this volume.

   d. Dry the bag.

6. Place the bag in a location as directed by the teacher.

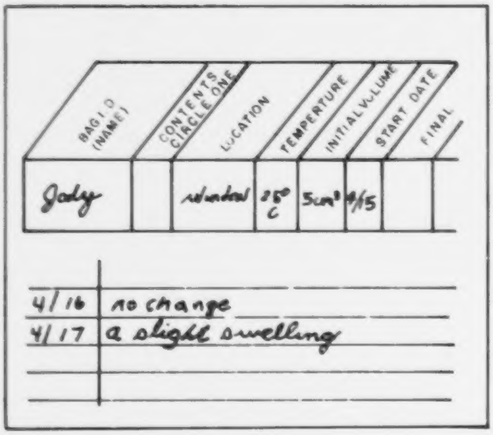
   a. Within each group, students (P) select one warm location and one cool location.

   b. Students (A) follow the same procedure.



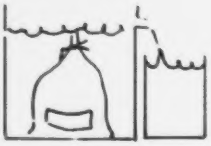
   c. Record the location on the masking tape with grease pencil. Suggested locations:

      - in a shaded or cool part of the room (20°)
      - near a window with sunlight, or near a heater (25°C)
      - in an incubator, or under a warming box where the temperature can be maintained at about 32°C.



BAG I.D (NAME)	CONTENTS CIRCLE ONE	LOCATION	TEMPERTURE	INITIAL VOLUME	START DATE	FINAL
Jody		window	25° C	5cm³	4/5	

4/16	no change
4/17	a slight swelling



7. On the "INDIVIDUAL DATA SHEET," record the bag identification, what is inside the bag, the location of the bag, temperature of the location, the initial volume, and starting date.

8. Every day look carefully at your bag. On the daily observation chart, record any changes (or no changes) for 5 to 10 days, or until some of the bags in the class seem to be nearly full of gas.

9. Record the location and type of waste in the bags that seem to be the most nearly full.

10. To find the estimated final volume of your bag and its contents, submerge the closed bag in water. Record the findings.

WORKSHEET

INDIVIDUAL DATA RECORD: METHANE

BAG I.D. (Name)	CONTENTS (circle one)	LOCATION	TEMPERATURE	INITIAL VOLUME	START DATE	FINAL VOLUME	FINAL DATE	VOLUME CHANGE	GAS PRODUCED
	(P) ------------ (A)								

DATE	OBSERVATIONS

AE-46

Analyzing results

1. Compare the amount of gas generated by your systems with that of others in your group. Which system(s) seemed to produce the most? least?

   ____

2. What factors (variables) influenced the production of gas?

   ____

LIQUID FROM BIOMASS

Introduction

By the process called "destructive distillation," substances such as wood can be converted to useful products which are different in form and appearance.

Observe the demonstration carefully and record what happens. Answer the following questions:

1. When heat was applied to the wood, did it burn with an obvious flame?_____ Describe what you saw. ______________________________

   ____

   Describe the remains of the wood in the flask after the destructive distillation process was complete (color, other properties).

   ____

   ____

   ____

3. How did the odor of products compare with the odor of wood?

   ____

   ____

   ____

4. What term(s) describes the odors produced by the destructive distillation process?

   ________________ ________________ ________________

5. Describe the substance collected in the test tube (color, odor, etc.).

   ____

   ____

6. Do any of the products of destructive distillation have any of the same properties as wood? If so, list them.

   ________________ ________________ ________________

LIQUIDS AND GAS FROM BIOMASS:
A SUMMARY

1. How were the odors from the two processes alike/different? Consider both the starting materials and the end products.

2. Compare the appearance and physical states of the products from the two processes.

3. What are the undesirable aspects of using these two processes to obtain alternative energy sources?

4. What are the desirable aspects of using these two processes to obtain alternative energy sources?

WASTE INCINERATION DEMONSTRATION

USE WITH:
General Science
Mathematics

TIME:
2 class periods and one week assignment

MATERIALS:
A sharp tool
5 gallon can
Scales capable of weighing a person
Worksheets (included)

Objectives

The student will:

1. Demonstrate the advantages and disadvantages of using trash as fuel.
2. Research some communities that are using their trash as a source of energy (allow time to receive information, unless acquired ahead of time).

Background Information

We live in the most wasteful society in the history of the world. The amount of household waste from the average American home is staggering; few families generate less than two garbage cans of trash per week. Packaging, important in modern business, is a major source of household waste.

Look at what you buy at the grocery store. When you bring your purchases home, if you put only the product to be consumed in one pile and the containers and wrappings in another, which pile will be larger? For example, when you purchase aspirin, you get a paper sack, a box that holds a bottle, the bottle which contains the aspirin and a piece of cotton, and you have a paper receipt. Eventually, everything is thrown away except the aspirin. In most communities, this trash is buried in a landfill even though the trash may contain valuable metals such as aluminum. Trash also has a high energy content. Waste incineration facilities burn trash not only to get rid of it but also to use it as a source of energy.

Procedure

1. Waste generation

    a. Discuss with students our "throw-away" lifestyles and ask them to give examples of things they use once and throw away, based on their own experiences. Give each student a copy of "DATA SHEET: HOUSEHOLD TRASH." Ask students to weigh their daily household trash (including garbage) discarded each day. Household trash can be weighed on regular bathroom scales. The student holds the trash in a bag and weighs himself/herself; then the student weighs himself/herself again not holding the trash; the difference in weights is the weight of the trash. Students continue to weigh their trash each day for one week, keeping accurate records of the amount of trash generated each day.

Example:

150 pounds (Student weight with trash)
-135 pounds (Student weight without trash)
15 pounds (Weight of trash)

b. Ask students to make a list of the different kinds of materials in their trash; e.g., paper, food stuffs, metal cans, bottles, etc. (This information will be used in No. 2.b.)

c. At the end of one week, have students find the total weight of the trash generated by the families of all members of your class. Ask each student the number of members in his/her household. Find the sum of the number of members of all the households. Divide the total weight of trash by the total number of members of all the households represented in your classroom; divide that by seven to find the average amount of trash produced daily by each person.

Example:

Total weight of trash for one week for the class is 300 pounds.

Total number of persons in the families is 80 people.
300 pounds per week / 80 persons = 3.75 pounds per person per week.

Weight of trash per person is 3.75 pounds per week.
3.75 pounds per week / 7 days per week = 0.5 pounds per person per day.

Daily average weight of trash per person is 0.5 pounds.

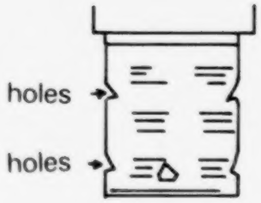
d. Ask students to find the population of their community (city or county). Multiply the daily average number of pounds of trash per person by the number of people living in your city or county. That is approximately how much trash your community generates each day. (You may want to figure the annual amount as well and convert it to tons.)

Example:

20,000 (population)
x .5 lbs. (daily average of trash per person)
10,000.0 lbs. (approximate trash generated daily)

2. Waste incineration

a. Obtain a 5 gallon metal can and a sharp tool. Make air vents near the bottom of the can. This will be the TRASH INCINERATOR; the holes are necessary for air to circulate so that burning is efficient.



b. Arrange with the Home Economics teacher (or school cafeteria) for students to obtain mixed trash (paper, food stuffs, etc.). (Students can use the lists they made in No. 1.b. to determine a typical mix.) Students then fill the TRASH INCINERATOR with trash that would normally be set out for the garbage truck and record the weight of the trash.

c. Outdoors, if possible, have students place the trash in the TRASH INCINERATOR. Place a metal pan containing water on top of the TRASH INCINERATOR. Record water temperature.

d. Burn the trash as thoroughly as possible. Have students record the highest temperature that the thermometer reads. Ask them: What environmental problems does this burning immediately create? What environmental problems does it solve? CAUTION: Some communities have ordinances about burning trash. Check with the fire department for help with this activity during dry periods. (Invite a member of the fire department to supervise the incineration.)

e. Help students to find the amount of heat energy given off in Btus by the burned trash. Discuss with the class how the heat generated might be used.

3. Waste reduction

a. When burning is complete and the TRASH INCINERATOR is cool, pour the ashes and unburned remains into a sack. Record the weight of ashes and remains.

b. Have students: Subtract the weight of trash after incineration from the weight before incineration; divide the difference in the weights by the weight before incineration; then multiply that by 100. (This is the percentage which burned.)

Example:

1. 30 lbs. (weight of unburned trash)
   − 5 lbs. (weight of trash after burning)
   25 lbs. (weight of trash burned)

2. 25 pounds / 30 pounds = .83

3. .83 x 100 = 83%

c. Ask students: Was a large percentage of trash burned? What advantage is there to burning, other than the energy gained (assuming you could put that energy to good use)?

Less land needed for landfilling.

Discussion

1. Based on the estimated daily amount of trash produced by the members of your community, how much trash is generated per year?

2. Using the percentage of trash that burned in your incineration demonstration, how much trash reduction would result in your community if the trash were burned in an incineration plant which controls air pollution and uses the heat produced?

3. List the advantages and the disadvantages of burning household waste.

Advantages	Disadvantages
1. reduction of volume	1. produces air pollution (needs scrubber on smoke stack)
2. easy to accomplish	2. could create fire hazard
3. inexpensive	3. charred products still must be disposed of

4. Would trash incineration be good for your community? Why?

   Have students list the advantages and disadvantages; then, have students compare the advantages and disadvantages that they listed for burning household waste.

5. Discuss ways to capture and distribute for use the energy created from burning household waste. Hint: The metropolitan area of Nashville is the location for a unique method of using waste to generate energy. Obtain information about it by writing:

Nashville Thermal Transfer Corporation
110 First Avenue South
Nashville, TN 37201
Attn: General Manager
Telephone (615) 244-3150

6. Extension:

   a. Investigate how the ashes from burned waste could be used for soil conditioning on farms, lawns, or gardens.

   b. What was the volume of trash originally and after burning? What percentage of volume reduction occurred?

   c. Investigate and discuss the relative amounts of energy needed to produce one pound of aluminum from its mineral source in soil with the amount needed to reclaim one pound of aluminum by recycling cans, foil, etc.

Name ______________________

Period ______________________

DATA SHEET: HOUSEHOLD TRASH

All persons dispose of a large amount of trash and waste material each day. We would like to find out how much material is being thrown away. The data that you and each of your classmates record will help to do this.

Use the following chart to record the trash and garbage that is produced by the people in your household. The trash is to include newspapers, trash from the trash cans, as well as the garbage from the kitchen. On some days it may be necessary to take more than one measurement.

Data needed for each day:

Your weight while holding the trash (as indicated on the bathroom scale) minus your weight only equals the weight of the trash.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Weight of you and trash							
Less your weight							
Weight of trash							

Total weight of trash for one week. ____________ pounds

Number of persons in your home. ____________ people

WIND ENERGY - MEASURING WIND SPEED

USE WITH:
Earth Science
General Science
Physical Science
Physics

TIME:
3-5 class periods

MATERIALS:(groups of 3 students)
Ping-Pong ball
Dark thread, 8" long
Used file folder
Paper clip
Small weight (like 1 oz. fishing wt. or 2-3 1/2" flat washers)
(classroom)
Stapler
Long sewing needle for teacher
Tape dispenser
Worksheets (included)

Objectives

The student will:

1. Demonstrate understanding of the feasibility (practicality) of using wind as an energy source.
2. Construct a device to measure wind speed.
3. Calculate average wind speed.
4. Determine whether or not wind provides sufficient energy to produce electricity in the local area.

Background Information

Difference in solar radiation, the atmosphere, and the surface of the earth produce uneven heating and cooling on the earth's surfaces. This uneven heating produces air motion, which we refer to as wind.

Wind may be as gentle as a breeze, gusty, or as strong as a tornado or hurricane. It is the wind which helps to control climate (including rainfall) and moderates rapid changes in temperatures.

Wind has been used as an energy source for a long time. One example of this is using wind energy to pump water. Today we are using high altitude jet streams to faciitate the speed of airplanes, which saves fuel.

But there is a problem in attempting to harness wind energy to produce electricity; wind does not blow with a constant speed or from a consistent direction. Generating electricity requires a constant wind speed of at least 13 kilometers per hour (km/hr.).

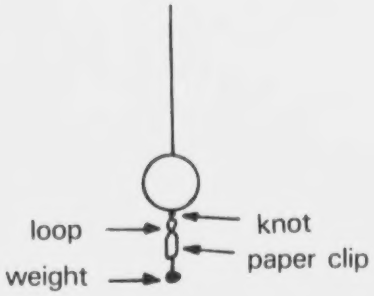
Procedure

I. Making a Wind Speed Detector

   A. Ask students to list some of the earliest uses of wind as an energy source.

B. Explain to students that a wind speed of 13 km/hr or more is needed to generate electricity. The wind speed is needed to produce an adequate force on the blades of a wind generator for it to turn with sufficient speed to generate electricity. Lower wind speeds may turn the blades, but not fast enough for generating electricity. Is wind a viable (workable) option for use as an energy source in your community? Ask students to identify where they could get daily or hourly information about wind speed in the local area.

C. Direct students, in groups of 3, to assemble a wind speed detector, using the student sheets "WIND SPEED DETECTOR" and "PROTRACTOR PATTERN." Prepare a ping-pong ball for each group (or demonstrate for students, letting them prepare ping-pong balls): thread needle with an 8-inch piece of thread, push needle through ping-pong ball; knot end of thread so that there is a small loop of thread below the knot to hold ball; glue the knot. Open paper clip; hook one end over thread loop and, with the other end, hook the weight.



II. Recording Wind Speed

A. Have each group of 3 students use the Wind Speed Detector to determine the wind speed at a location near the school: near an entrance, between buildings, on windward (direction from which wind blows) and leeward (direction to which wind blows) sides of buildings, on football field, etc. (Each group selects a different location.) The student sheet "MEASURING WIND SPEED" provides detailed information for this activity.

B. Have students use the student sheet "WIND SPEED DATA SHEET" to record wind observations at different times during the day for the next 3 to 5 days. (OPTION: Students could continue collection data throughout the school year, including several seasonal changes. Also, data collected from different class periods could be compiled and km/hr.

III. Data Treatment

A. Give each group of copy of the "BEAUFORT SCALE OF WIND SPEED" to be used as a reference for converting km/hr to miles per hour (mph). Students are to enter this number on their data sheets. OPTION: Students could convert km/hr to mph and use the Beaufort Scale to check their work.

B. Have students construct bar and/or line graphs to better display data. Have students draw a line on the graph at 13 km/hr. This line will enable students to see quickly how the data entries compare with the wind speed necessary to generate electricity.

C. Have students make another graph to show the wind speed at all the locations where data was collected by the class.

D. Ask students to compare the wind speeds at various locations, such as on the windward and leeward sides of the building. Compare the highest reading with the readings at the other locations taken at the same time.

Discussion

1. Can wind be used to generate electricity in your community? If so, discuss some likely locations. If not, what is the problem? Can the problem be overcome? What would need to change?

   The answer here will depend upon your geographic location and topographic considerations. Use student-gathered information as the basis for your answers.

2. How feasible is wind as an energy source in mountain passes? What problems exist there?

   In some mountainous areas, winds are intermittent but very powerful. They are not reliable, and uncertain direction (down slope or up slope) is a problem.

3. Is wind power a renewable/nonrenewable or depletable/nondepletable resource?

   This is a discussion question for the purpose of having students examine word definitions and viewpoints. Accept any answer that has a logical basis.

4. What are some positive and negative aspects to wind as a source of power?

Advantages	Disadvantages
free	not reliable
nonpolluting	not available at some places
locations	initial costs are high

5. What is the field of study that deals with wind speed data? What is the name of a person who works in this field? What data other than wind speed is collected by a person in this field?

   Meteorology is the science that deals with weather and weather conditions. A meteorologist is a scientist who works in this field. Other meteorological data include wind direction, precipitation, air pressure, cloud formation, temperature, etc.

6. Extension:

   a. Have students compare their findings with the television or radio weather reports. Do they differ? How? Why?

   b. Discuss with students the significance of the length of string holding the ping-pong ball. How will the angle of displacement be affected by a given wind speed (force)? Prove conclusions mathematically and verify by taking readings using different string lengths.

   c. What are land and sea breezes? Where do they occur? What would be necessary to use them to generate electricity? How did the Netherlands use them in the past?

      Sea breezes occur in the early morning and evening along coastal areas because of unequal temperature changes of land surfaces and water masses. The wind direction changes every 12 hours, so not only would the wind speed need to be 13 km/hr but the generator would need to change direction according to the wind direction.

   d. Have students measure the wind around their homes, in a tree-covered area, in the middle of a field, etc., and record their data for making comparisons later in class. Does the time of the data collection make a difference? Should the time of day be recorded? Why?

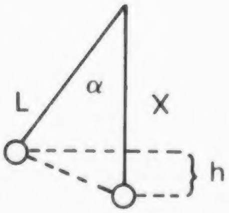
   e. Ask students to make reports on the modern wind turbine.

   f. Ask students to make models or drawings of the different kinds of wind turbines.

   g. For advanced students: After recording the angle, have students calculate the potential energy created by the wind.

      - Weigh the ping pong ball.

- Use trigonometry to determine how high the ball was lifted.



$$P.E. = mgh$$

$$h = L - X$$

$$\text{Cos } \alpha = \frac{X}{L}$$

$$X = L \text{ Cos } \alpha$$

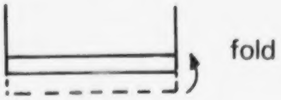
$$h = L - L\text{Cos } \alpha = L(1 - \text{Cos } \alpha)$$

$$P.E. = mgl(1 - \text{Cos})$$

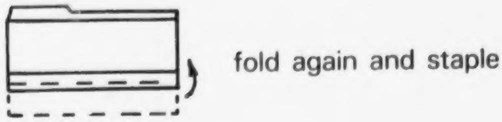
- What potential energy is created by the wind at the various locations used by class members?
- What potential energy is created by a wind speed of 13 km/hr?
- What preliminary conclusions can be reached based upon these observations and calculations?
- What are some other data that should be collected to more fully answer the previous questions?

WIND SPEED DETECTOR
Instruction for Assembly

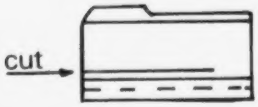
1. The frame (file folder, scissors, stapler)



With the file folder closed, fold the long edge of the folder 1" to 2" on the side that is prefolded.

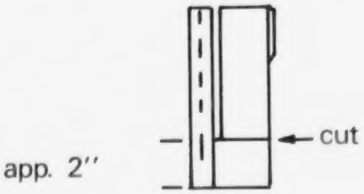


Fold it a second time, and staple the folded layers together at 5 to 6 places from one end to the other.



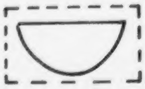
Cut along the edge of the folded layers to within 2" of the end.

Cut across the protrusion - perpendicular to the folded layers - 2" from bottom.

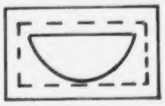


2. The protractor (pattern, scissors, tape)

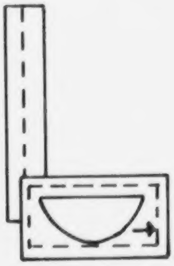
Cut the protractor from the page along the dotted line.



Tape the protractor to one section of the remaining file folder.



Tape this entire "protractor" to the extension of the frame, so that the straight edge of protractor is at the top.

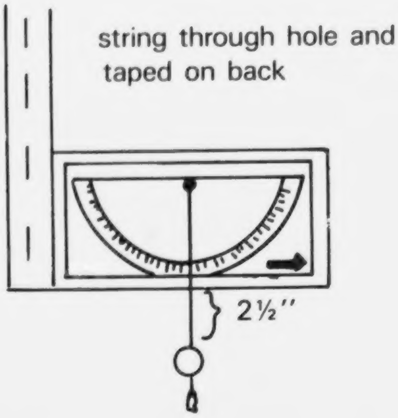


3. The ping-pong ball (ball with thread and weight, tape)

See teacher for this part.

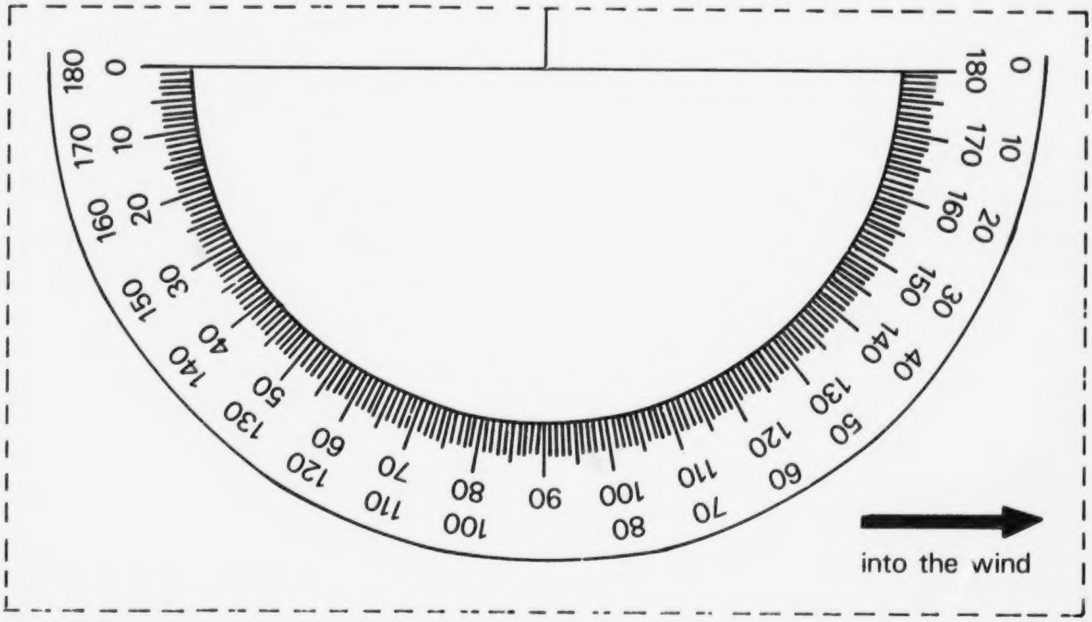
Punch a small hole in the protractor's center dot and pass the thread through the hole. Knot the thread and tape firmly to back of protractor, so that the thread measures 2-1/2" from bottom of protractor to ball.

Be sure that when the protractor is held level, out of the wind, the thread, ball, and weight hang at exactly 90°.



PROTRACTOR PATTERN

1. Cut on dotted line.

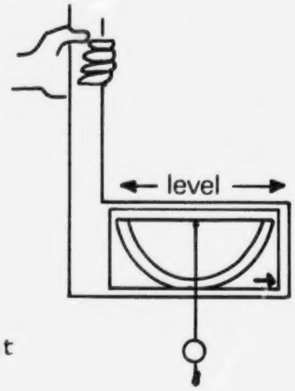

0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
into the wind

2. Tape to a backing sheet (file folder, tablet back etc.).
3. Tape to frame.
4. Tape thread at center mark.

MEASURING WIND SPEED

1. On the "WIND SPEED DATA SHEET," enter the date, time, and location of the site where data are going to be collected.
2. Face into the wind and hold the Wind Speed Detector at arm's length in front of you so that:

   a. the flat edge of the protractor is level with the ground, and
   b. the protractor arrow is pointing into the wind, and
   c. the ball can swing freely in the wind, and
   d the thread hangs at exactly 90°.



Angle	Wind Speed km/h
90°	0
85°/95°	6.5
80°/100°	13
75°/105°	16
70°/110°	19
65°/115°	21.5
60°/120°	24
55°/125°	26.5
50°/130°	29
45°/135°	31.5
40°/140°	34
35°/145°	37
30°/150°	41
25°/155°	46
20°/160°	52

3. A partner carefully removes paper clips and weight. (To improve accuracy of data collection, practice before recording measurement.) Record the number of the highest angle that the thread reaches on the protractor when the ball is pushed by the wind.

4. Use the chart at the right of this sheet to find out what that angle reading indicates in wind speed, measured in kilometers per hours (km/hr). Record that speed on the data sheet.

5. After you finish collecting data, mathematically convert km/hr to miles per hour (mph). Refer to left-hand column on "BEAUFORT SCALE OF WIND SPEED" to check your work. Record this speed in the right-hand column on the "WIND SPEED DATA SHEET."

Example:

WIND SPEED DATA SHEET

Location football field

Date	Time	Angle	km/hr.	mph
October 25	8:30 a.m.	110°	19	12

Student Name

Student Name

Student Name

WIND SPEED DATA SHEET

Location

DATE	TIME	ANGLE	KM/HR.	MPH

BEAUFORT SCALE OF WIND SPEED

The Beaufort scale describes the speed of wind on the basis of its observable effects.

SPEED	KIND OF WIND	WHAT YOU CAN OBSERVE
≅ Up to 1.6km (1 mi) per hour	Calm	Smoke rises vertically
≅ 1.6 to 5 km (1 to 3 mi) per hour	Light air	Smoke drifts
≅ 6 to 19 km (4 to 12 mi) per hour	Gentle breeze	Leaves and twigs move
≅ 21 to 29 km (13 to 18 mi) per hour	Moderate breeze	Dust and loose paper move
≅ 30 to 50 km (19 to 31 mi) branches move per hour	Strong breeze	Small trees sway; large
≅ 51 to 74 km (32 to 46 mi) per hour	Moderate gale	Whole trees move; twigs break off trees
≅ 75 to 86 km (47 to 54 mi) per hour	Strong gale	Some structural damage
≅ 88 to 101 km (55 to 63 mi) per hour	Whole gale	Trees uproot; much structural damage
≅ 102 to 122 km (64 to 75 mi) per hour	Storm	Widespread damage
≅ Over 122 km (75 mi) per hour	Hurricane	Very extensive damage

IS THERE AN "ULTIMATE" ENERGY SOURCE?

USE WITH:
General Science
Language Arts
Social Studies
Chemistry
Physics
Economics

TIME:
5 class periods plus library research

MATERIALS:
Film: "Why Man Creates"
Film: "Search for Solutions: Trial and Error"
Worksheet (included)

Objectives

The student will:

1. Determine which energy sources are best for the community in which he/she lives.
2. Discuss the potential for global problems based on energy and other natural resource shortages.
3. Research the advantages and disadvantages of various alternative energy technologies.
4. Use a creative process to invent a "futuristic" energy device.

Background Information

No single energy source can supply all the needs of all the people. For example, solar energy is less available in Washington State than in Arizona; and the wind does not blow as often in Tennessee as it does on the plains of Kansas and Oklahoma.

Primary energy sources in the near future for the Tennessee Valley will be fossil fuels, nuclear, hydroelectric, and solar. But what about the future beyond that? As our energy options change, our needs and behaviors will change.

We live in an age of rapidly advancing technology that can provide solutions to our quest for a quality environment in which to live. But since research efforts have not yet produced a "unique" inexhaustible energy source to meet our needs at this time, we must become the "dreamers" for the future. We must be able to change from one energy source to another as disadvantages of availability, economics, and environmental quality begin to outweigh advantages. Individuals can participate in the decisionmaking process for our energy use. The lessons we have learned from the past can help us wisely manage our energy resources in the future.

The major purpose of this activity is for teachers to encourage and reward the use of imaginative and innovative thinking. Imaginative and innovative thinking will be required to solve some of our energy problems in the future.

Procedure

I. Advance preparation.

Order the films "Why Man Creates" and "Search for Solutions: Trial and Error" from the source listed at the end of this activity.

II. Gathering data.

A. Show the first segment of the film "Why Man Creates." Ask students what they saw in the film that related to our need for energy. Ask students, "What was significant in the last part of segment I?"

B. Assign each student to research one of the alternative energy sources listed on the "CHART - ALTERNATIVE ENERGY: CHARACTERISTICS PRO OR CON." Material developed in previous lessons may be used. Each student is to develop a report and present it orally to the class.

NOTE: Reports should include:

1. Amount of energy produced (use most recent data).
2. Amount of energy consumed in the production, transmission, and end-use (final use) of the alternative energy.
3. Environmental impact.
4. Cost to consumer.
5. Process that created the alternative energy source.

C. Provide students with copies of the chart, or copy it on the board or a flip chart. After each report is presented, have each student complete the chart as reports are made, and discuss with students the information related to each box on the chart.

D. Following the discussion, ask each student to submit a written response to the questions:

1. Which alternate energy source, or combination of sources, is best for our community?

2. Why? (The reasoning behind the answers will be as significant as the learning of the facts.)

III. Analyzing alternative energy sources.

After students identify and discuss several alternative energy sources, use the following questions to reinforce the study, especially regarding the responses in "II.D."

A. Which source produced the most energy?

B. Which source consumed the most energy in its production, transmission, and use?

C. Which source had the least environmental impact?

D. Which source was the most expensive to the consumer?

E. What was the process which created each source?

F. What are some energy sources that have not been used?

IV. The search for solutions

A. Ask students:

1. Did you ever fry a hamburger? How did you know when it was done?

2. Did you ever bake a cake or cookies? How did you know when it was (or they were) done?

3. Did you ever work a jigsaw puzzle? How did you find the correct pieces?

4. Did you ever try to learn to swim, dive, play a guitar, drive a car, speak another language, do a cartwheel, focus a camera or a microscope? How did you learn to do it?

B. Tell students that they are going to see a film about some people who had problems to solve. Show the film "Search for Solutions: Trial and Error."

1. After the program, discuss with students:

a. The basic problems that faced the people.

b. The methods used by the people to overcome their problems.

c. The single most important factor about each person that allowed him or her to accomplish the task.

2. Discuss with students the Background Information about this activity and the need to search for the solutions to our energy problems. For example, what is the limit to the energy that a human being can supply for his or her own purpose, such as flying? How did the Gossamer Condor illustrate the possibilities of succeeding at something that was considered to be impossible?

V. Pursuing New Ideas

A. Tell students that many new sources of energy are being researched for fueling spacecrafts. Ask students to describe how energy might be harnessed from the sun to provide energy needs on a space station (e.g., food production, heating, etc.).

   1. List all the energy needs of a spacecraft.

   2. Examine the "STUDENT GRID" and fill in the blank spaces with any other possible energy sources.

B. Tell students that new sources of energy are being researched for energy needs right here at home. These needs are just as important as our needs for space travel, and the search for solutions can be just as exciting. Someone sitting in a high school classroom today will help to solve our energy problems for tomorrow.

   1. Have students complete the left-hand column by adding names of devices they find in their homes or community that use energy.

   2. Have students write across the top of the grid any additional idea(s) they might have for an energy source.

   3. In the grid example, the "X" indicates a geothermal home heating system. Brainstorm with students some possible combinations, rewarding and reinforcing student development of unique ideas. Be certain that all of the boxes are explored, because a "far out" idea may lead to one that is exceptionally creative.

   4. Students may work individually, in small groups, or as a class to develop an "invention." Encourage students to "GO WILD" with their ideas! Some important discoveries and inventions began as a "WILD IDEA."

   5. Students should each draw a sketch and describe how their "inventions" operate, list the advantages and disadvantages, and describe what they think the prospects are for the actual development of their most creative "inventions."

   6. Have students write reports on their most creative inventions and share reports with the class, and let the class select the three most creative ideas with the best potential for being used. Post the top three ideas and submit them for publication in the school newspaper.

   NOTE: Advanced science students could use this to develop a science fair project.

Discussion

1. Would all parts of the Tennessee Valley, the United States, or the world, be adaptable to the various energy sources identified on the "CHART?" Why? Why not?

   No. For example: the sun does not provide sufficient energy per square foot in the northern latitudes; there are not as many "hot springs" and other geothermal sources in the Tennessee Valley as are found in some of the more rugged, mountainous regions of the Far West and Northwest; tides are generally not as useful in large lakes as they are in coastal areas; and hydroelectricity is limited to a source of running water that can be impounded. However, nuclear power can be used in most areas if an adequate water supply is available.

2. Which source on the "CHART" would create the greatest problem if the supply were to become depleted?

   Hydroelectricity.

3. Which source is most important to you, and why?

   Hydroelectricity, because it is clean, and relatively low in cost, and might not become depleted if we manage our forests and drainage basins correctly.

4. Extensions:

   A. Ask students to look in the library for recent articles on new energy sources, and to contact research organizations regarding recent findings. (The Department of Energy, (202) 252-8800, might be a source for names of agencies to contact.)

   B. Ask students to research one "new" source of energy that interests them the most. Ask them to include in the report how much energy could be tapped from the source and for what use?

Resource

Films:

Pyramid Films. Why Man Creates. (Write: Box 1048, Santa Monica, CA 90406.), n.d.

Karol Media. Search for Solution: Trial and Error. (Write: 22 Riverview Drive, Wayne, NJ 07470.), n.d.

EXAMPLE: STUDENT GRID

ENERGY	HOME HEATING	GROUND TRANSPORTATION	HOME LIGHTING	FOOD PRODUCTION	PERSONAL AIR TRAVEL	ROAD CONSTRUCTION
Solar Winds						
Biophotolysis						
Wind						
Water						
Solar						
Moon Rocks						
Geothermal	X					
Photo-Electrolysis						
Gravity						
Biomass						
Photosynthesis						
Space Dust						

X indicates a home heating system using geothermal energy as a source of heat.

412

ALTERNATIVE ENERGY: CHARACTERISTICS - PRO OR CON

Energy Source	Local Availability	Fuel Cost	Pollutants (air, water, thermal, noise	By-products (waste or usable	Is the technology now available?	Expense of the System	Other Considerations
Animal power (including human)							
Geothermal							
Hydroelectric							
Nuclear fission							
Nuclear fusion							
Solar							
Magnetohydrodynamics							
Hydrogen fuel cells							
Tidal power							
Waste Incineration							
Wood							

Glossary

Alcohol:	an organic compound containing a hydrocarbon group and one or more hydroxyl (OH) groups.
Anaerobic digestion:	a process in which microorganisms decompose organic material without the presence of oxygen.
Bioconversion:	the changing of energy from one form to another by the action of plants or animals.
Biomass:	plant materials (in any form from algae to wood) and animal waste materials.
Biophotolysis:	a process by which plants use light energy to break down compounds.
Briquets:	bricks made of compressed coal dust, sawdust, or charcoal; used for fuel.
Btu:	British thermal unit; a unit which measures the quantity of heat required to raise the temperature of one pound of water one Fahrenheit degree.
Calorie:	the amount of heat needed to raise the temperature of one gram of water one Celsius degree.
Calorie:	short for Kilocalorie; the amount of heat that will raise the temperature of one kilogram of water one Celsius degree.
Cellulosic:	a product or material made of the cell walls or fibers of plant tissue.
Celsius:	a temperature scale, in which, under laboratory conditions, 0 degrees is the freezing point of water and 100 degrees is the boiling point for water.
Consumption of energy:	the amount of energy used; identified as to the energy source (like coal, gas, etc.).
Convert:	to change from one form to another; transform
Cord:	a unit of wood cut for fuel; equal to 4' x 4' x 8', or 128 cu. ft.

Creosote:	a substance resulting from burning some woods; a residue from the distillation of wood.
Depletable:	able to be used up or exhausted.
Derivative:	something taken from another source; not original in form; an extract of something.
Digester:	a strong, pressurized, steam-heated vessel used to produce methane from organic wastes.
Distill:	to extract one substance from another.
Distillate:	any of the substances separated from another substance and then collected.
Distillation:	a process by which a substance is vaporized, condensed, and then collected as a liquid.
Dri-gas:	a name given to a group of manufactured products, which, when added to gasoline, are claimed to remove water; most of these products contain a high percentage of alcohol.
End-use:	energy used for work, heating, etc. directly (not changed to a different form of energy).
Environmental:	pertaining to all that surrounds an organism.
Ethanol:	C_2H_5OH (structurally CH_3CH_2OH); formed by fermentation or decomposition of sugars or starches.
Ethyl alcohol:	a clear, colorless liquid which burns; C_2H_5OH (structurally CH_3CH_2OH); ethanol, grain alcohol.
Feasible:	capable of being done or carried out.
Ferment:	to break down an organic material by the action of microorganisms; when fruit rots, it ferments.
Fossil fuel:	fuel made from the fossil remains of organic materials; coal, crude oil, or natural gas.
Gasohol:	a mixture of 90 percent gasoline and 10 percent alcohol.

Geothermal:	having to do with the heat from within the earth.
Grain alcohol:	same as ethyl alcohol, but made from grain; C_2H_5OH (structurally CH_3CH_2OH).
Herbaceous:	green and leaf-like plants, like vegetables or flowers; not such woody plants as trees and shrubs.
Hydrocarbons:	compounds containing only hydrogen and carbon; all burn in air and none pass electric current.
Hydroelectricity:	electrical energy produced when falling water is used to turn a generator; damming rivers and streams forms man-made waterfalls for the production of hydroelectricity.
Incineration:	burining of something to ashes in the presence of oxygen.
Intermittent:	stopping and starting again; pausing from time to time.
Isopropyl alcohol:	a clear, colorless, flammable liquid, C_3H_8O (structurally $CH_3CHOHCH_3$).
Joule:	the unit of energy measurement in the International System; the amount of work done by one newton acting through a distance of one meter.
Kilocalorie:	the amount of heat needed to raise the temperature of one kilogram of water one Celsius degree; also called Calorie.
Landfill:	the place where community garbage and rubbish is buried under shallow layers of soil.
Leeward:	the side of an object sheltered from the wind; the front side of a person who is standing so that the wind is coming from behind him.
Liquefaction:	the process of turning a solid or gas into a liquid.
Magnetohydrodynamics (MHD):	(magnetohydrodynamics) the study of the properties of conducting fluids in magnetic fields.
Meteorology:	the study of weather and climate.

Methanol:	a colorless, flammable, poisonous liquid; obtained from wood; methyl alcohol; CH_3OH; can be formed by adding hydrogen to carbon monoxide over a catalyst that was originally produced by destructive distillation of wood; thus, the term "wood alcohol."
Nondepletable:	not able to be used up or exhausted.
Nonrenewable:	not able to be restored; unable to be made new again or replenished.
Organic:	chemical compounds containing carbon.
Paraffin:	a white, waxy, odorless, tasteless solid mixture produced as a by-product in the refining of oil.
Particulates:	the small solids (like soot and ash) suspended in the gases produced by combustion.
Petrochemicals:	chemicals derived from petroleum or natural gas.
Photochemical:	a chemical reaction produced by using the effect of light.
Photoelectrolysis:	a process which uses light to cause the movement of electrons in a solution to produce a chemical change.
Production:	a term used to indicate the amount of fuel made available for use during a specified time.
Propane:	colorless, gaseous hydrocarbon with three carbon atoms per molecule; C_3H_8; a common "bottled gas" used for fuel.
Renewable:	able to be restored or made new again.
Reserves:	a term used to indicate how much of an existing energy souce could be made available, using current technology.
Sludge:	mud or ooze covering the ground or forming a sediment at the bottom of a liquid.
Solar cell:	a device that changes the energy of sunlight into electric energy.
"Throw away" lifestyle:	people frequently using things once and then disposing of them.

Tidal energy (power):	energy derived from the ocean water level rising and falling along coastal areas.
Topography:	the surface features of land (like mountains and valleys).
2-propanol:	a clear, colorless, flammable liquid, C_3H_8O (structurally $CH_3CHOHCH_3$); also known as isopropyl alcohol.
Viable:	workable and likely to survive.
Wind power:	energy derived from moving air.
Windward:	the side of an object facing the wind; the back side of a person who is standing so that the wind is coming from behind him
Wood alcohol:	methyl alcohol; CH_3OH; poisonous.

References

"Agricultural Feedstocks of the Future." Alternative Sources of Energy 63 (1983): 58-60.

"Army Tests Methane as Helicopter Fuel." Aviation Week and Space Technology 120 (16 January 1984): 135.

Bennett, G. "Dutch Wind Power Not In Vain." New Scientist 100 (27 October 1983): 268.

Blazej, A. "Processing a Vegetable Raw Material into Fuel and Organic Products; One of the Possiblities for Replacing Mineral Raw Material." Ropa a Uhlie (Czechoslavakia) (1982): 385-97.

Bolton, J. R. "Solar Cells - A Technology Assessment." Solar Energy 31, no. 5 (1983): 483-502.

Bungay, H. R. Energy, The Biomass Options. New York: Wiley Interscience, 1981.

DaSilva, E. J. "Biofuels and Their Generation from Biomass: An Overview." Vol. 1 of Fuel Gas Production from Biomass, D. L. Wise, ed. Boca Raton, FL: CRC Press, 1981.

Dell, R. M. "Hydrogen as a Future Alternative Fuel." Journal of the Institute of Energy 53, no. 416 (1980): 116-9.

Ehrenreich, H. "Comments on Current Photovoltaic Technology." Solar Cells (1984): 45.

"Energy and Man - Yesterday, Today, and Tomorrow." Compressed Air 83 (January 1978): 6-11.

Eveleigh, D. E. Biomass Utilization. New York: Plenum Press, 1983.

Ferber, R. R. "Photovoltaic Power - An Important New Energy Option." Mechanical Engineering 105 (December 1983): 16-23.

Hodgman, C. D., R. Weast and S. M. Shelby. Handbook of Chemistry and Physics. Cleveland: Chemical Rubber Publishing Company, n.d.

"Hybrid Windmill Maintains Power Output in All Winds." Mechanical Design (1983): 84.

Karol Media. Search for Solution: Trial and Error. (Write: 22 Riverview Drive, Wayne, NJ 07470), n.d.

Paul, S. "Forest Biomass and Wood Energy Systems." Bio-Energy Re-News (1983): 16-25.

Pyramid Films. Why Man Creates. (Write: Box 1048, Santa Monica, CA 90406.), n.d.

"Small Hydropower Dam to Produce Hydrogen." Hydropower (1980): 17.

"Sunny Side Up." Mechanical Engineering 105 (December 1983): 80-4.

Trainer, F. E. "The Limitations of Alternative Energy Sources." Conservation and Recycling (1984): 27.

"Wind Blows Cool." Nature 306 (1 December 1983): 412.

SPECIAL PROJECTS

Overview

In this section of the Energy Sourcebook, abstracts of learning activities developed by individual teachers are presented. Each of these special projects has been implemented by high school groups in the Tennessee Valley. The teachers report a high degree of student interest and participation. An especially attractive feature of some of these projects is community involvement and the practice of energy-wise, environmentally positive behaviors.

If more details or specific plans are needed, the developers may be contacted directly. However, these activities can also serve as suggestions for similar projects especially suited to the needs and the resources of any school or group of students.

IN CHARGE

(Energy Workbook for Special Education Students)

In Charge is a workbook to aid in energy education for high school educably mentally handicapped students. In special education, a main goal is to prepare students to cope with the world around them. Energy education can be seen as highly relevant to this goal in that energy is such an important factor in the lives of all people.

Two key objectives of the workbook are to increase student awareness of the role energy plays in their lives and to increase understanding of the different energy sources and how they are used. The overriding message of In Charge is energy conservation.

The workbook included self-explanatory activities and is designed for a six-week course of study, although the time may be adjusted for student ability. Also included are pre- and posttests, class activities, field trip suggestions, a glossary and a bibliography of reference materials.

Developer: Dannie McCarley
Muscle Shoals High School
Muscle Shoals, Alabama 35661

Copies available in limited quantities from:

Public Service Programs
Johnson Environmental & Energy Center
The University of Alabama in Huntsville
Huntsville, Alabama 35899

Environmental/Energy Education Program
Division of Land and Economic Resources
1C40 Old City Hall Building
Knoxville, Tennessee 37902

INTRODUCTION TO ENERGY SOURCES AND USE

(Computer-Assisted Instructon)

Twelve computer-assisted instruction (CAI) energy-related science activities have been developed to provide individualized instruction in special energy topics. Energy use, fossil fuels, conservation, nuclear energy, synthetic fuels and renewable energy sources are covered following a pretest, tutorial with posttest format. They were developed for use on a TRS-80 Model III or Model IV (in Model III mode) disk system with a 32K memory. The activities are stored as data files on an unformatted data disk. Users must transfer them to their own TRS DOS formatted disks. A "student program" provided by Fireside Computing Inc. (5843 Montgomery Road, Elkridge, MD 21227) accesses the data files. The activities were created using an authoring system developed and owned by Fireside. A written glossary and a written comprehensive pre- and posttest are also provided.

Developer: Howard L. Rhodes, Jr.
Bradshaw High School
Florence, Alabama 35630

ALTERNATIVE ENERGY TECHNOLOGIES

(Computer-Assisted Instruction, Supplemental Lessons)

These Computer-Assisted Instruction (CAI) lessons are appropriate as enrichment or extra credit work or simply as supplements for regular classroom coverage of developing alternative energy technologies. They may be used with either middle or high school students.

Five topics are covered on three tutorial diskettes. The first diskette deals with biomass energy and includes demands for energy and the desirability of conserving nonrenewable energy resources. The second covers direct solar energy (active and passive systems) and wind energy. The third diskette contains lessons on geothermal energy and hydropower. Each topic is followed by a quiz.

This project uses the Apple Superpilot Authoring System for the Apple IIe computer, allowing a classroom teacher who is not a trained programmer to create customized lessons using advanced graphics, animation, sound and special character sets. The diskettes are easily copied using Copy A Program or any other system copy program.

Developer: Guy McClure
Athens High School
Athens, Alabama 35611

SPENT STEAM

(Action Research and Community Involvement Project)

This project is directed toward increased awareness of industry as a partner in energy conservation. By researching energy conservation measures taken by industry in their area, students learn not only more about industrial energy usage but also about possible methods of saving energy.

The first step is to find out what industries are located in the area around the school. Their energy uses are determined, and energy waste is identified. The class must research industrial processes enough to know how to suggest as ways to save energy. Participation in this project results not only in cognitive development, but also in greater awareness of the links between company and the community in which it is located. In addition, relationships between the school and industry are built.

Developer: Michael Jones
Pisgah High School
Canton, North Carolina 28716

DO WINDBREAKS CONSERVE ENERGY?

(Class Research and Community Action Project)

Student participation in a community service project for energy conservation can be coupled with participation in class research. In this project, the class is divided into groups which research different factors in wind velocity, airflow, wind chill factor and windbreak design. Each group must formulate, present and discuss ideas; then the class as a whole must make a collective decision on a windbreak design and its potential as an energy saver.

This information can be disseminated in the community so that citizens can use it. It is possible that the state forestry service could cooperate to distribute tree seedlings through class members. Such a project benefits both students and the community.

Developer: Joe Milam
Russellville High School
Russellville, Kentucky 42276

THE SUNBOX PROJECT

(Construction of a Multipurpose Sunbox and Activities)

Students tend to view solar energy in a futuristic way. This project helps students view solar energy as more practical and immediately useful by using it to do a variety of household and garden jobs. By constructing and testing a solar device that would be useful around their homes, students can compare the use of solar energy to that of electricity or gas.

The class may be divided into groups to research and discuss design proposals for the "sunbox", after which it must collectively decide on a design. If there is not time for this activity, the developing teacher's design may be used. Although the sunbox must be somewhat large (about 4' x 2.5') to be useful in some tasks, most of the materials can be obtained free or at little cost, making this an affordable project for almost any school.

Once the sunbox is constructed, it may be tested with a variety of simple demonstrations. It can then be used for drying wood, fruits and vegetables, seed or wet clothing; for germinating seeds; for thawing frozen items; or any number of tasks often accomplished with conventional energy sources.

Developer: Joe Milam
Russellville High School
Russellville, Kentucky 42276

THE SOLAR OVEN PROJECT

(Construction of a Solar Cooker and Activities)

An inexpensive solar cooker can be built following a plan such as that in Organic Gardening, August 1980. With the solar cooker, a number of activities encompassing many areas of study can be done. Library research papers can enhance writing skills, various computations utilize math skills, and even cooking skills may be developed.

The project description includes instructions for 10 specific activities which help students become more aware of the ways energy from the sun can be harnessed and used for everyday tasks.

Developer: Mary Clemens
Pisgah High School
Dutton, Alabama 35744

WASTE ENERGY? NOT ME!

(Creative Projects for a Class and Individual Students)

As a follow-up to a unit on energy conservation, students may write, perform and film a play about home energy waste and conservation. This activity generates much enthusiasm and requires a great amount of cooperation between class members. The resulting film may be used to promote energy conservation in the school, students' homes and the community.

A more individual project is designing energy-efficient housing. Plans highlighting energy-saving features can be drawn and shared with the class accompanied by oral presentations.

Developer: Ruth Morgan
Warren Central High School
Bowling Green, Kentucky 42141

YESTERDAY'S YARDSTICK - TOMORROW'S TECHNOLOGY

(Creative Class Project)

This videotape production project can be made as simple or as complex as deemed necessary or desirable. This project encompasses creative writing, history, science, performing, taping and editing. It is very time-consuming but produces a resource which can be a permanent addition to the school's tape library.

There is a script available for this particular title, but, as a creative project, there is much room for variation. Like this production, a project may examine historical aspects of TVA and the Tennessee Valley, or it may deal with any other aspect of energy, energy use/conservation, or the energy/environment interface.

Developer: Alicia Brown
Sedalia High School
Mayfield, Kentucky 42066

GOOD TO THE LAST DROP

(Activities on Motor Oil Use and Waste)

A preliminary exercise in which students become more familar with motor oil is followed by the collection and measurement of wasted oil from discarded cans. The data collected by the students is then extrapolated to gain an estimate of the amount of oil wasted in the United States each year. A main point is that the energy potential of this oil is lost, and there are also environmental aspects of the problem.

This topic is an excellent example of how a simple everyday practice taken for granted, can be a contributor to a much larger problem. Possible solutions to the problem comprise the closure of the unit.

Developer: Joe Milam
Russellville High School
Russellville, KY 42276

WIRING SWITCHES FOR ENERGY CONSERVATION

(Vocational Education for Energy Conservation)

In any vocational education course where electrical wiring is taught, up-to-date methods of wiring for energy conservation can be stressed. Of particular importance is delivering full voltage for maximum appliance efficiency, the installation of thermostats and automatic timers, and proper placement of switches to encourage less energy waste.

Successful completion of wiring projects as well as student production of an instructional videotape reinforce classroom learning.

Developer: Pat Henderson
Breckinridge County High School
Harden, KY 40146

ELECTRICAL ENERGY - A TRIP TO PARADISE

(Classroom Unit and Field Trip)

A unit of study on electricity can incorporate classroom study activities, speakers from local utilities, and a field trip to an electrical generating facility. This trip to Paradise Steam Plant, a coal-burning plant, included a guided tour of an operative surface mine adjacent to the power plant.

The unit includes a follow-up session using slides taken on the field trip to review and make closure for the study. This organization of the unit makes excellent use of resources in the community and dramatically increases student understanding of the subject matter.

Developer: J. Pat Stewart
Warren East High School
Bowling Green, KY 42101

SOLAR ENERGY SIMULATION

(Computer-Simulated Research)

This special project is a computer simulation of a solar energy research project. It was developed from an experiment in Solar Energy Experiments on solar heat gain in a closed automobile by Thomas W. Norton and was modified to apply to houses rather than cars. The program was expanded to include calculations of the thermal resistances of various building materials.

Originally a class project for an advanced class, this study has become an independent study project for students seeking enrichment. The program has been reworked and is now operational on Apple, TRS 80, and VIC 64 computers.

Developer: Billy Sensing
Lone Oak High School
Paducah, Kentucky 42001

PHOTOVOLTAIC STIMULATION: A PROCESS TO INCREASE PLANT GROWTH

(Experiment on Application of Solar Cells in Agriculture)

In the January/February 1984 issue of Mother Earth News, a short article suggests that photovoltaic root stimulation results in the increased growth of garden plants. A class research project was developed to test the effect of this solar energy application on green pepper and tomato plants (50 each in both the control and experimental groups). Careful records of conditions (e.g., temperature), variables such as amounts of water administered, and plant gowth were kept. The experimental group showed increased growth, as expected.

This special project may be adapted to any group by varying such lesson components as the degree to which statistical procedures are applied to the data collected by the students.

Developer: Linda Barrett
Camden Central High School
Camden, Tennessee 38320

EQUIPMENT AND MODELS

OVERVIEW

In this section of the Energy Sourcebook is a series of activities to be used with specific equipment and models: a bicycle generator, a heliodon, a solar pathfinder, and a compass with a sunfinder. Each set of activities was developed and tested in the classroom by high school teachers in the Tennessee Valley.

The activities were developed to be used with classes from physics to environmental science, and to provide knowledge directly related to utilizing solar energy, conservation, and the production of electricity.

If similar models or equipment are already available to your school, you may need to adapt some of the activities to fit the model to which you have access. If the equipment is not available through your school, each of TVA's power district offices has each item to lend to teachers. You may request more than one Solar Pathfinder and compasses for use with your students, but there will be only one bicycle generator and one heliodon available for loan at each district office. The sunfinder is found at the end of the compass activities in the Energy Sourcebook and may be copied for use.

For more information on how to obtain the equipment and models, contact the district office nearest to your school. Addresses and telephone numbers follow for each office.

POWER DISTRICT OFFICE CONTACTS FOR EQUIPMENT AND MODELS ARE:

ALABAMA DISTRICT:
Communication Supervisor
501 First Federal Building
Florence, Alabama 35630
(205) 386-2051 or -2431

APPALACHIAN DISTRICT:
Communication Supervisor
200 Brookvale Building
Knoxville, Tennessee 37909
(615) 632-6750

CENTRAL DISTRICT:
Communication Supervisor
Box 110140
Nashville, Tennessee 37222
(615) 360-1562

KENTUCKY DISTRICT:
Communication Supervisor
Box 1088
Hopkinsville, Kentucky 42240
(502) 885-4357

MISSISSIPPI DISTRICT:

Communication Supervisor
Box 470
Tupelo, Mississippi 38802
(601) 842-5825

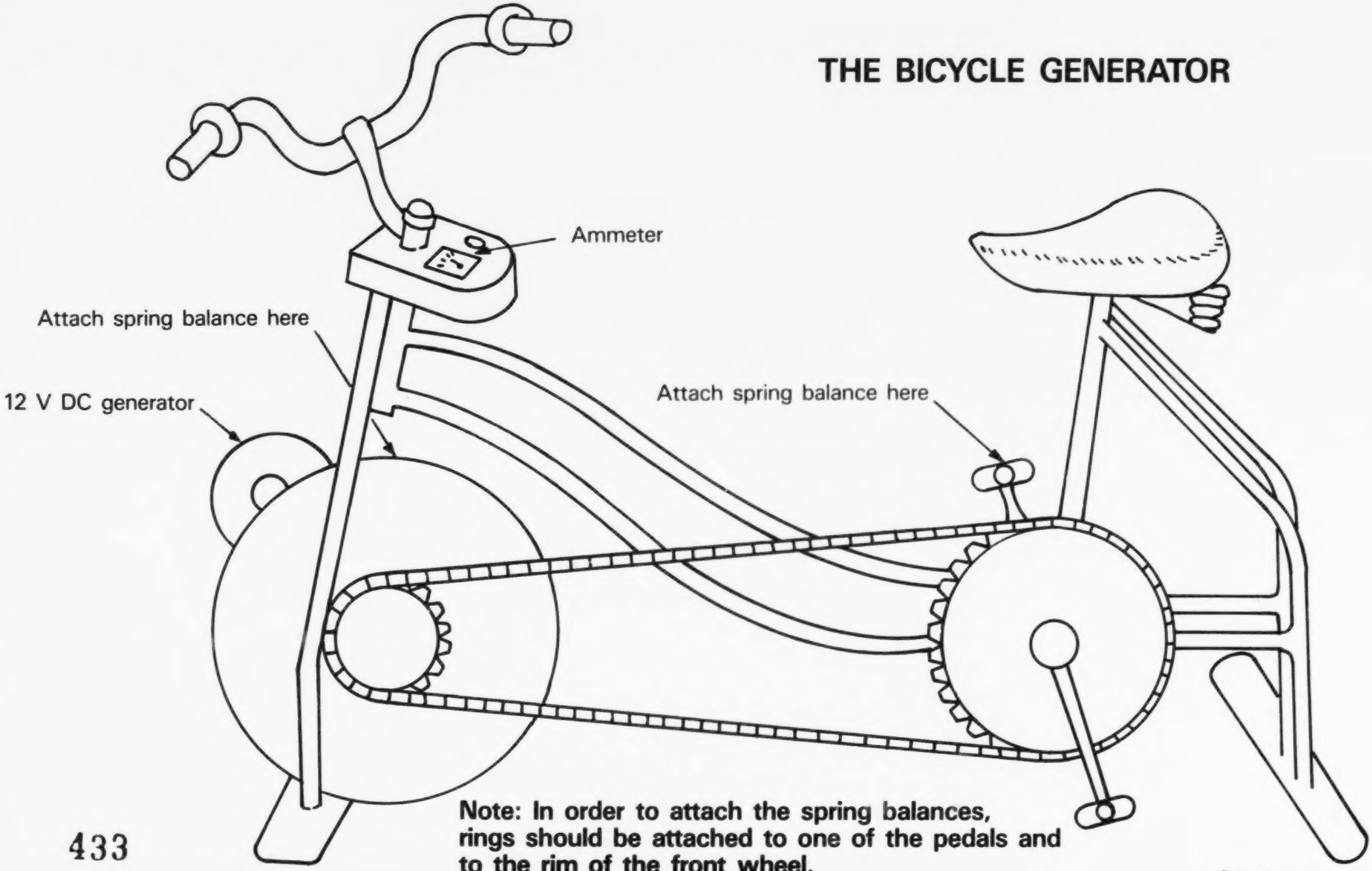
SOUTHEASTERN DISTRICT:

Communication Supervisor
1709 South Lee Highway
Cleveland, Tennessee 37311
(615) 478-1141

WESTERN DISTRICT:

Communication Supervisor
Box 999
Jackson, Tennessee 38301
(901) 668-6100

THE BICYCLE GENERATOR


Ammeter
Attach spring balance here
12 V DC generator
Attach spring balance here

Note: In order to attach the spring balances, rings should be attached to one of the pedals and to the rim of the front wheel.

USE WITH:
General Science
Physical Science
Physics

TIME:
1 class period

MATERIALS:
Bicycle generator
Meter stick
Spring balance
(0-2000g or 0-20N)
Worksheet (included)

BICYCLE GENERATOR: #1

WORK IS ENERGY

Objectives

The student will:

1. Measure the work done while pedaling a bicycle.
2. Measure the work transferred from pedals to the front wheel.

Background Information

Energy is the capacity to do work and is measured in the same units as work (Joules). Thus, work and energy are totally interchangeable under ideal conditions. Work is defined as force operating over a given distance and is equal to force multiplied by distance ($W = Fd$). It can then be said that a change in potential energy is also equal to a force operating over a distance ($PE = Fd$). This potential energy can be converted to kinetic energy ($PE = KE$).

Procedures

1. Review definitions of energy and work and units of measurement in this activity.

2. Explain instructions and demonstrate how the bicycle generator works.

3. Divide the class into groups of 4 or 5 students. Allow each group enough time to complete the activity.

4. Follow with discussion questions.

Discussion

1. Compare the work done at the pedals and at the front wheel. Why are they different?

   Work done at front wheel is less than work done at pedals; i.e., the machine does not convert all the energy to useful work. No machine has perfect efficiency.

2. If work and energy are the same, where did the energy come from that eventually produced the force that turned the pedal? Trace the path of this energy from its original source.

   Sun Food Muscles Motion

Instructions

1. Using the bicycle generator, attach a spring balance to one of the pedals at an angle that is perpendicular to the radius of the path of the pedal. Pull until it starts to turn. Record this force in Table 1.

2. Attach a spring balance to the rim of the front wheel of the bicycle generator and pull at an angle that is perpendicular to the radius of the wheel until it starts to turn slowly. Record.

3. Determine the distance the pedal travels in one complete turn. This is the circumference of the circle, a distance equal to the diameter of the path of the pedal times pi ($C = \pi d$). ($C = 2\pi r$ may also be used). Record. Remember to use meters as units.

4. Determine the distance the front wheel travels in one complete turn. Use the same method as in #3. Record.

5. Calculate work done at pedals and then at front wheel using $W = Fd$ for each (where d is the circumference in #3, then #4) or $W = F (2\pi r)$. (Remember, units of force are newtons.) If measurements are made in grams, convert first to kilograms, then multiply by 9.8 m/s^2 ($F = MA$). Record.

6. Repeat steps 1 thru 5 twice and record.

7. Average your results to get more accurate figures.

TABLE 1

TRIAL	FORCE AT PEDAL (N)	DISTANCE PEDAL MOVES (M)	WORK DONE AT PEDAL (J)	FORCE AT REAR WHEEL (N)	DISTANCE REAR WHEEL MOVES (M)	WORK DONE AT REAR WHEEL (J)
1						
2						
3						
AVERAGE						

USE WITH:
General Science
Physical Science
Physics

TIME:
1/2 class period

MATERIALS;
Bicycle generator
Table 1 (from Activity 1)
Worksheets (included)

BICYCLE GENERATOR: #2

THE BICYCLE AS A MACHINE

Objectives

The student will:

1. Compare the work input to the work output.
2. Calculate the mechanical advantage of the bicycle.

Background Information

A machine is a device that multiples force at the expense of distance or that multiplies distance at the expense of force. There are six types of simple machines: the lever, the inclined plane, the wheel, the axle, the wedge, the pulley, and the screw. All other machines are either combinations of two or more of these or modifications of them. A machine can multiply force, but it cannot have more work output than input. This would violate the Law of Conservation of Energy (Energy can be transformed but is never destroyed or created by ordinary means.) Work is lost due to friction ($W_{in} = W_{out} + W_{Friction}$). The efficiency of a machine is the ratio of W_{in} to W_{out} ($EFF. = \frac{W_{out}}{W_{in}} \times 100\%$).

The mechanical advantage of a machine is an expression of the number of times the force is multiplied. There are two types of mechanical advantage: the ideal mechanical advantage and the actual mechanical advantage. The ideal mechanical advantage (IMA) is equal to the distance moved during work input divided by the distance moved during work output.

$$IMA = \frac{D_{in}}{D_{out}}$$

The actual mechanical advantage (AMA) is equal to the force created during work output divided by the force required during work input.

$$AMA = \frac{F_{out}}{F_{in}}$$

Thus, the actual mechanical advantage takes friction into consideration.

A bicycle makes use of a modified wheel and axle, transferring the force from the pedals to the large wheel by a chain. The work input occurs at the pedals. The work output occurs at the wheel being turned by the chain.

Procedure

1. Review definition of machine.
2. Discuss limitations on efficiency of machines.
3. Using Table 1 (from Activity 1), go through instructions with students.
4. Supervise activity.
5. Follow with discussion.

Discussion

1. Compare the Actual Mechanical Advantage to the Ideal Mechanical Advantage. Why are they different?

   The AMA is smaller than IMA. Work is lost due to friction.

2. What happens to the work lost due to friction?

   It is changed to other forms of energy; heat and sound are generated.

3. Why is a perpetual motion machine an impossibility?

   If no more energy is put in to maintain the work, the amount of work put out will proportionally decrease in comparison to the amount of energy lost as friction.

4. Energy is always in short supply in the world's economy. How does this activity relate to this scarcity?

   Much energy is lost due to friction in using machines. Most machines have efficiencies of less than 50 percent, so much energy is wasted.

Instructions

1. Using the data from Table 1, calculate work lost due to friction ($W_{Friction} = W_{in} - W_{out}$). Record in table 2.
2. Using the data from Table 1, calculate the efficiency of the bicycle (Eff. = $\frac{W_{out}}{W_{in}}$ x 100%). Record.
3. Using the data from Table 1, calculate the Ideal Mechanical Advantage (IMA = $\frac{D_{in}}{D_{out}}$). Record.
4. Using the data from Table 1, calculate the Actual Mechanical Advantage (AMA = $\frac{F_{out}}{F_{in}}$). Record.

TABLE 2
FOR ACTIVITY 2

WORK LOST DUE TO FRICTION (J)	EFFICIENCY (%)	IDEAL MECHANICAL ADVANTAGE	ACTUAL MECHANICAL ADVANTAGE

USE WITH:
General Science
Physical Science
Physics

TIME:
1/2 class period

MATERIALS:
Bicycle generator
Stop watch or watch with second hand
Data from Table 1 from Activity 1
Worksheet (included)

BICYCLE GENERATOR: #3

POWER

Objectives

The student will:

1. Measure rate of pedaling the bicycle generator.
2. Calculate power.

Background Information

In physics, power is simply the rate of doing work. Thus, power takes the time factor into consideration.

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

James Watt, an 18th century scientist and inventor, first developed the unit called the horsepower, which was the equivalent of an average horse's rate of work. Since horses aren't as common as they were in Watt's day, the metric unit, the watt is more commonly used today. A watt is one Joule per second (1W = 1J/s). A machine that does work at the rate of 1J/s has a power of 1 watt. The power needed to lift a glass of water is approximately 1 watt. Because that is a small quantity, power is more commonly measured in

Procedure

1. Review previous terms and concepts.
2. Introduce power and units thereof.
3. Go through instructions with students.
4. Supervise activity.

Discussion

1. Compare the power developed by the bicycle rider in the first trial to the power developed in the second trial. Was the second trial "harder work"?

   2 times as much, yes. The second trial resulted in twice the power (twice the work in the same period of time).

2. Would it be possible for a bicyclist to generate 400 watts of power?

   No. One could not pedal that hard.

Instructions

1. Using a stopwatch, or the second hand on a watch, pedal the bicycle generator for one full minute.

2. Count the number of revolutions of the large front wheel of the bicycle. (Try 60 per minute for the first trial. This rate can be obtained by having a student count the rate from 1 to 60 out loud.) Record in Table 3.

3. Obtain the calculated total amount of work done (Joules) from Table 1. Record.

4. To obtain the amount of work per second, divide the value from #3 by 60 seconds ($P = \frac{W}{T}$). Record

5. Repeat steps 1 through 4, but at a faster rate of 120 revolutions per minute. Record all data in Table 3.

TABLE 3

TRIAL	NUMBER OF REVOLUTIONS PER MINUTE	TOTAL WORK DONE (J)	POWER (J/sec or watts)
1	60		
2			

USE WITH:
General Science
Physical Science
Physics

TIME:
1 class period

MATERIALS:
Bicycle generator
Stop watch or watch with second hand
Voltmeter (0-15V)
Ammeter (0-10A)
Lead wires
Worksheet (included)

BICYCLE GENERATOR: #4

POWER IN ELECTRIC CIRCUITS

Objectives

The student will:

1. Measure the flow of electrical energy generated by the bicycle generator.
2. Calculate the power of this electrical current.

Background Information

The concepts of energy, work, and power apply to all forms of energy, not just mechanical energy. Electrical energy is no exception. To move an electrical charge through a wire requires a force. Thus, we have work ($W = Fd$). Power is the rate of doing work. Therefore, in electric circuits, power is the rate at which electrical energy is delivered to the circuit. The same unit for power in mechanical devices, the watt, is used for electrical circuits.

In electric circuits, the power used by an electric device is found by multiplying the voltage by the current ($P = VI$, where I is amperes). Thus, 1 watt of power would be used by a device requiring a potential difference of 1 volt (J/C) and a current of 1 ampere (C/S), where C is the coulomb. Using the formula to calculate the power, substitutions may be made as follows to calculate wattage:

$$P = VI$$

$$P = \frac{J}{C} \times \frac{C}{S}$$

$$P = \frac{J}{S} = \text{Watts}$$

The bicycle generator makes use of a small DC electric generator to change mechanical energy into electrical energy.

Procedure

1. Apply concepts of energy, work, and power to electrical energy.
2. Discuss electric current, voltage, amperage, Joule, coulomb, and watt.
3. Go over instructions with students.
4. Direct data collection and calculations.
5. Follow with discussion.

Discussion

1. How is an electrical device like a mechanical device?

   They both require a force exerted over a distance.

2. Theoretically, what would happen to the electrical power if one pedaled twice as fast?

   It would double.

3. What current would be necessary to generate 36 watts? 4 watts?

   $$P = VI$$

   $$I = \frac{P}{V}$$

   $$I = \frac{36W}{?V} = ? \text{ and } I = \frac{4W}{?V} = ?*$$

*Amperes of current cannot be calculated without voltage amounts from activity.

Instructions

1. Attach the ammeter to the electrical contacts on the generator.
2. Operate the bicycle generator at the rate of 120 revolutions per minute for 1 full minute, reading the ammeter every 10 seconds. Record these six values in Table 4. Average them and record.
3. Attach the voltmeter to the electrical contacts on the generator.
4. Repeat step 2, reading the voltmeter every 10 seconds. Record these values and their average.
5. Calculate the power of the bicycle generator from the average values using the formula P = VI. Record in the table below.

TABLE 4

TRIAL	VOLTAGE (V)	CURRENT (A)
1		
2		
3		
4		
5		
6		
AVERAGE		

Power = ______________ watts

USE WITH:
General Science
Physical Science
Physics

TIME:
1/2 class period

MATERIALS:
Data from Tables 3 and 4 from Activities 3 and 4
Worksheet (included)

BICYCLE GENERATOR: #5

ENERGY: CHANGES IN FORM

Objectives

The student will:

1. Compare the mechanical output of the bicycle to the electrical power generated by it.

Background Information

Energy is a basic concept in physics and all science. There are thousands of transformations in forms of energy going on around us every day. When you walk, you are using energy that has gone through several forms, originating with nuclear reactions on the sun. All these transformations occur according to the Law of Conservation of Energy (Energy can neither be created nor destroyed). This is not to say that energy transformations are 100 percent efficient. None of them are. For example, when chemical energy (in a battery) or mechanical energy (in a generator) is changed to electrical energy, much energy is lost due to friction and results in heat. This heat is transferred to the surroundings and therefore is not usable. The total amount of energy in the niverse is conserved, but energy which becomes unavailable to us is termed "lost" energy.

With the bicycle generator, mechanical energy is changed to electrical energy with a corresponding loss of energy. Remember, no energy transformation is 100 percent percent efficient.

Procedure

1. Review energy transformations and Law of Conservation of Energy.
2. Review calculation of efficiency.
3. Direct students in calculations.
4. Follow with discussion.

Discussion

1. How many watts of power are lost during this transformation of energy?

   Answers will vary between 4 and 8 watts.

2. Most transformations of energy are no more efficient than the bicycle generator. If energy transformations were 100 percent efficient, how would the world's energy supply be affected?

   We would have an abundance of energy resources because all resources used would be used with perfect efficiency (no waste or loss).

Instructions

1. Transfer the watts of mechanical power developed by the bicycle generator from Table 3, Trial 2 (120 rev. min.) to Table 5.

2. Transfer the watts of electrical power developed by the bicycle generator from Table 4 to Table 5.

3. Calculate the efficiency of the transformation of energy

   (Efficiency = $\frac{\text{Energy output}}{\text{Energy input}}$ x 100%). Record in Table 5.

TABLE 5

BICYCLE POWER: MECHANICAL (W)	BICYCLE POWER: ELECTRICAL (W)	EFFICIENCY OF CHANGE (%)

USE WITH:
General Science
Physical Science
Physics

TIME:
1 class period

MATERIALS:
Bicycle generator
and appliances
Worksheet
(included)

BICYCLE GENERATOR: #6

WHAT APPLIANCES CAN BE POWERED BY A BICYCLE GENERATOR?

Objectives

The student will:

1. Collect electrical data from various household appliances.
2. Calculate the amperage required by the appliances.
3. Test the calculations using the bicycle generator.

Background Information

In electrical circuits, the power used by an electrical device is found by multiplying the voltage by the current ($P = VI$) (see Activity 4). Thus, the current is equal to the power divided by the voltage.

$$I = \frac{P}{V}$$

Common household circuits (and the output to devices attached to the bicycle generator) utilize 115 volts AC current. Household appliances have a label attached indicating the wattage and voltage used by the appliances. Therefore, the amperage used by each appliance can be calculated.

Procedure

1. Connect the provided appliances to the bicycle generator so students can test its ability to operate them. Have other equipment (e.g., small pieces belonging to the school) available for students to test.

2. Explain calculation of amperage from given voltage and power.

3. Supervise student data collection and use of generator. Take special care that appliances are used safely and correctly.

4. Follow with discussion.

Discussion

1. Which of your predictions were correct? Incorrect?

2. There is a limit to the amount of energy the bicycle generator can produce. Is this true of the energy resources in nature?

   Yes

3. If the bicycle generator were your only source of power, how would it affect your lifestyle?

Instructions

1. Operate the bicycle generator. Do all the appliances work?

2. Determine the power demand, in watts, of the the appliances. The total alternating current (AC) voltage available is 115 volts. Using the formula

$$I = \frac{P}{V}$$

calculate the amperage required by the devices.

3. Examine several small appliances. Record their wattage requirement in Table 6. (Assume their voltage requirement to be 115V.)

4. Calculate the current needed for each appliance. Record.

5. Predict which appliances will operate on the bicycle generator. Record your predictions in Table 6.

6. Test each appliance on the generator to see if your predictions are correct.

TABLE 6

APPLIANCE	VOLTAGE (V)	POWER (W)	CURRENT (A)	PREDICTION (Yes/No)	TEST (Yes/No)

USE WITH:
General Science
Physical Science
Physics

TIME:
1 class period

MATERIALS:
Bicycle generator and appliances
Data from Table 6 from Activity 6
Worksheet (included)

BICYCLE GENERATOR: #7

COST OF ELECTRICITY

Objectives

The student will:

1. Calculate the number of students needed to operate 3 devices with the bicycle generator for 24 hours.
2. Calculate the amount of electricity produced by the bicycle generator in 24 hours.
3. Calculate the value of the electricity produced by the bicycle generator.

Background Information

Electrical energy is very convenient. Flip a switch and lights, televisions, air conditioners, refrigerators, and other machines all work. We are generally unaware of the amount and cost of the electricity we use.

The quantity of electricity used is calculated by multiplying the power by the time (Energy = Pt) and is expressed in kilowatt hours (1 kilowatt hour = 1000 watts x 1 hour). Since electricity is sold in kilowatt hours, the cost of electricity is calculated by multiplying the number of kilowatt hours used by the cost per kilowatt hour. Call the local electric company to find out the cost per kWh of electricity.

Procedure

1. Obtain the cost per kWh of electricity from the local utility.

2. Attach appliances for operation by bicycle generator.

3. Explain concept of kilowatt hour. Give utility company-provided cost per kWh and explain calculation of electricity costs.

4. Direct activity.

5. Follow with discussion.

Discussion

1. Would it be feasible to use the bicycle generator to produce all the electricity needed for every-day uses?

   No.

2. How would lifestyles change if electricity were produced by human labor?

   Large-scale industry and most of the conveniences of modern life would probably not exist. Society would become labor-intensive, as it is in primitive or underdeveloped societies today.

Instructions

1. Pedal the bicycle generator hard enough to operate the 3 appliances attached. Could you continue at this rate for a day?

2. If a person could pedal this hard for 1/2 hour, how many people would it take to continuously operate all 3 appliances for 24 hours? Record in Table 7.

3. Calculate the amount of electricity used by the 3 appliances in 24 hours by using the formula Energy = Pt (P = Power in kilowatts and t = time in hours). Record.

4. Using the cost per kilowatt hour (supplied by instructor), calculate the total value of the electricity produced by the bicycle generator during a 24 hour period. Record.

TABLE 7

POWER USED BY 3 APPLIANCES (W)	POWER USED BY 3 APPLIANCES (kW)	TIME (hr)	AMT. OF ELECTRICITY USED IN 24 HR. (kWh)	COST OF ELECTRICITY USED PER kWh (¢)	COST OF ELECTRICITY FOR 24 HR. (¢)
		24			

Number of people required to operate bicycle generator for 24 hours if each pedals for 1/2 hour______________.

HELIODON: #1

USE OF THE HELIODON TO DETERMINE THE DIRECTION TO FACE A SOLAR HOME

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
2 class periods

MATERIALS:
Light meter
Heliodon kit
Worksheet (included)

Objectives

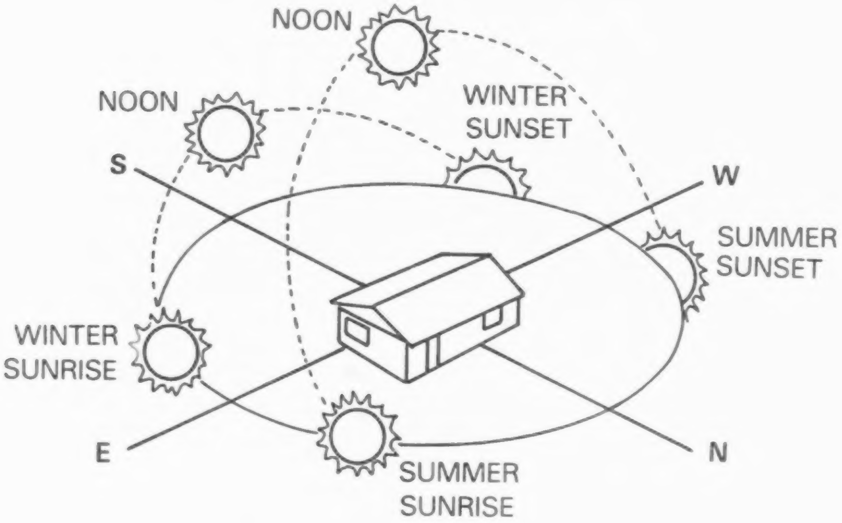
The student will:

1. Compare solar data for North, South, East, and West orientations of a solar structure.
2. Define a footcandle.
3. Define background light.
4. Determine the direction that a solar house should face to receive the maximum solar input.

Background Information

The first decision one must make when building a new solar home is which direction it will face. Is there an orientation that combines the best of energy performance, is attractive, and best suits the needs of the people living in the house? If so, the placement of the new home should take priority over some other considerations in order to realize the greatest energy savings.

In the Tennessee Valley, the solar arc reaches its highest point on the summer solstice (June 21) and its lowest point on the winter solstice (December 21.) On June 21 in the Tennessee Valley, the sun rises 15° north of due east and climbs to a noon peak of 78° altitude before setting 15° north of due west. On December 21, the sun rises 15° south of due east, reaches a peak of 32° altitude and sets 15° south of due west. Clearly, the winter arc is shorter and lower, and less solar energy is available.



Procedure

1. Following instructions in the heliodon kit, set up heliodon and demonstrate its use.

    a. Demonstrate to the students how to move the lights to position the sun for different times of the day.

    b. Identify the metal ring on the heliodon which represents the winter arc and the metal ring which represents the summer arc.

    c. Have the students agree on the position of different times of the day on each arc (e.g., 9 a.m., noon, 3 p.m.).

2. Demonstrate how to read the light meter. Explain the importance of the background light readings and how to substract them from total light readings for an accurate measurement of available light

3. Supervise activity.

4. Follow with discussion.

Discussion

1. Does orientation of the house have an effect on the amount of available light a solar house might receive?

    Yes, the most available light for the solar house is from the southern orientation.

2. Is there a difference in the amount of available light in the summer and winter?

    More light is available in the summer than in the winter due to the higher altitude and longer arc of the sun.

3. If this solar energy can be used to heat in the winter and cool in the summer, could it result in energy savings in a home?

    The use of solar energy could result in energy savings because this "free" energy from the sun could substitute for energy which would otherwise come from sources which have definite costs, both economic and environmental.

Instructions

1. Place solar house so that its front faces directly south on the board, and place light meter directly in front of the house.

2. Take a light reading from the light meter to account for background lighting. (NOTE: It may be necessary to increase or reduce the amount of light in the area where you are using the heliodon to ensure the proper use of the light meter.) Record in data table.

3. Place the light that represents the sun at the noon or highest position. Turn on the light and take a reading from the light meter. Repeat this procedure for the winter arc. Record the amounts of available light (determined by subtracting the background reading from the total readings).

4. Repeat steps 1 through 3 with your house facing north, east, and west for the summer and winter arcs of the sun. Record findings on the data table.

DATA TABLE

House Orientation	Summer Arc	Winter Arc	Background Reading	Available Light (Total light-background reading)
South				
North				
East				
West				

HELIODON: #2

THE EFFECT OF ORIENTATION ON THE PERFORMANCE OF A SOLAR HOUSE OR DEVICE

Objectives

The student will:

1. Determine the effect of orientation on the amount of light received by a solar device.
2. Determine the maximum shift in orientation which will not result in significant energy loss.

USE WITH:
General Science
Physical Science
Environmental Science

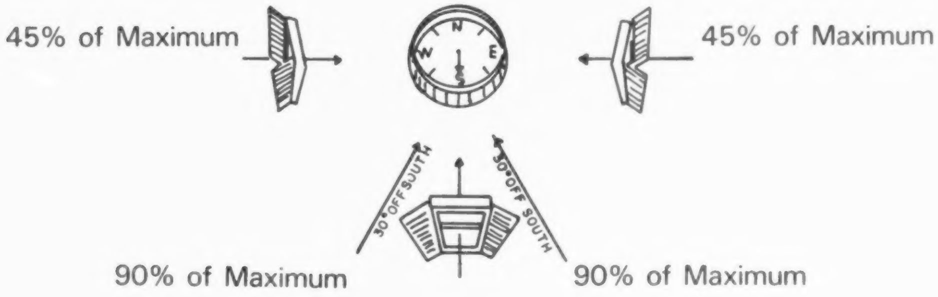
TIME:
2 class periods

MATERIALS:
Light meter
Heliodon kit
Worksheets (included)

Background Information

A solar house or device facing directly south receives the most available sunlight. What if it were not possible to face a house or device directly south because of aesthetic or other considerations? Is there a maximum deviation from true south orientation without a significant drop in solar energy?

Although true south is best, turning a solar device as much as 30° east or west of south will result in about a 10 percent reduction in available sunlight. A deviation of greater than 30° from true south may significantly reduce the effectiveness of a solar energy system.



Maximum Available Sunlight

Procedure

1. Following instructions in the heliodon kit, set it up and demonstrate its use.

2. Discuss with the students why the solar home faces south.

3. Explain how to determine the degrees of variance from the 4 directions marked on the heliodon. Demonstrate rotating the home 45°, 90°, and 180°. Demonstrate how to change the orientation of the solar house by 15 degrees.

4. Supervise students in activity.

5. Follow with discussion.

Discussion

1. Using the two sets of data, how much is the available light affected by a 15° shift in the orientation of the house?

   Reduction in available light should be noticed but may be greater than 5 to 10 percent for 0° to 15° and 15° to 30° shifts. Shifts of greater magnitude have a greater effect.

2. Do all shifts in orientation of 15 degrees cause an equal effect on the amount of available light?

   No; a greater drop in available light should be noted for a 30 to 45° shift.

3. What amount of shift dramatically affects the amount of available light?

   A 30° shift from true south should be the greatest allowable shift in orientation before the amount of light is dramatically affected.

Instructions

1. Face solar house directly south.
2. Take a background light reading and then position the sun at the 9 a.m., noon, and 3 p.m. positions for the winter arc and make light readings. Record your findings in the data table.
3. Then turn the solar house 15° east of south and repeat the readings for 9 a.m., noon, and 3 p.m. during winter. Record.
4. Now position house 30° east of south and repeat the three readings for winter. Record.
5. Position house 45° east of south and repeat the three readings. Record.
6. Repeat steps 1 through 5 for the summer arc of the sun. Record readings in data table.

DATA TABLE

WINTER

TIME OF DAY	DEVIATIONS FROM TRUE SOUTH			BACKGROUND LIGHT	AVAILABLE LIGHT (Total Light-Background Light)
	15°	30°	45°		
9 A.M.					
NOON					
3 P.M.					

SUMMER

TIME OF DAY	DEVIATIONS FROM TRUE SOUTH			BACKGROUND LIGHT	AVAILABLE LIGHT (Total Light-Background Light)
	15°	30°	45°		
9 A.M.					
NOON					
3 P.M.					

HELIODON: #3

SHADING FACTORS AFFECTING THE AMOUNT OF AVAILABLE SOLAR ENERGY

Objectives

The student will:

1. Identify factors that could affect the amount of available light for solar energy use.
2. Contrast the available solar energy in winter and summer seasons.
3. Demonstrate the effect on various types of shading on solar devices.

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
2 class periods

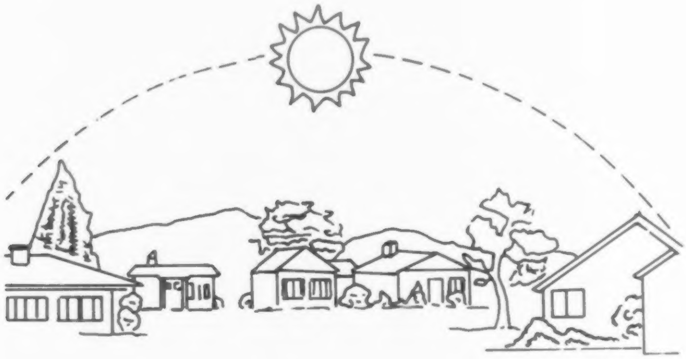
MATERIALS:
Heliodon kit
Light meter
Worksheets (included)

Background Information

Sunlight can furnish a large amount of heat in the winter. However, the sun also continues to supply heat during the summer months. To have a comfortable home, you must reduce the amount of heat in the summer and maximize it in the winter.

One way to do this is through carefully planned shading. Exterior shading devices are more efficient than interior devices because it is more effective to stop the sunlight before it enters the glass and is inside the house.

If a solar device is to be used, it must be positioned in such a way as to receive the maximum amount of solar energy. The establishment of a solar access zone is a way to ensure success of any solar device. A solar access zone is an area to the south of a solar device which is kept clear of large trees and other obstructions to sunlight.



Procedure

1. Following instructions included in the heliodon kit, set it up and demonstrate its use. Demonstrate how to read a light meter and explain the importance of the background light reading.
2. Have the students make a list of features that could shade a solar device.
3. Review the difference between deciduous and evergreen trees.
4. Discuss with the students the concept of an access zone.
5. Supervise activity.
6. Follow with discussion.

Discussion

1. Does shading have an effect in the summer?

   Yes, because sunlight can be blocked by a tree.

2. Does shading have an effect in the winter?

   This depends on the type of trees. Evergreens can shade solar devices significantly even in winter because they do not lose their leaves. Deciduous trees will have a lesser effect in the winter.

3. Do the types of trees (evergreen or deciduous) make a difference?

   Yes. Evergreen will offer shade year-round. This would be but a disadvantage in the winter.
   Deciduous trees offer shade in the summer and sunlight in the winter.

4. What are some considerations in establishing a solar access zone for a solar device?

   Some existing trees may need to be cut down. When planting new trees, decisions must be made about whether to use deciduous or evergreen trees as well as where to place them.

5. Using the following formula, calculate the percentage of blocking by trees with and without leaves for both summer and winter. Use the data from the table.

   $$\frac{\text{Amount of light received when shaded}}{\text{Amount of light received when unshaded}} \times 100\% = \text{Amount of sunlight blocked}$$

Instructions

1. Orient the solar house to the south on the heliodon surface. Place the tree models with leaves on them directly in front of the house. Take light readings for the 9 a.m., noon, and 3 p.m. positions on the summer arc. (Remember to take a background light reading first and then to subtract it from the total reading.) Record the available light amounts in the data table.
2. Repeat this procedure using the bare tree models instead of the leafed-out models. Record available light amounts.
3. Remove the tree models, and repeat the procedure to determine the available light with no shading. Record findings.
4. Repeat steps 1-3 for the winter arc. Record below.

DATA TABLE

SUMMER

TIME OF DAY	TREES WITH LEAVES	TREES WITHOUT LEAVES	NO TREES
9 A.M.			
NOON			
3 P.M.			

WINTER

TIME OF DAY	TREES WITH LEAVES	TREES WITHOUT LEAVES	NO TREES
9 A.M.			
NOON			
3 P.M.			

HELIODON: #4

AMOUNT OF SOLAR ENERGY AVAILABLE: WINTER VS SUMMER

Objectives

The student will:
1. Determine the amount of solar energy available during winter and summer.
2. Determine the amount of solar energy available at various times during the day.

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
2 class periods

MATERIALS:
Heliodon kit
Light meter
Worksheet (included)

Background Information

In a passive solar system, the rays from the sun penetrate directly into the house and the house itself becomes a solar collector. A good passive solar system requires careful positioning or orientation of the house to the sun.

The sun travels in an arc across the sky each day, reaching its highest point at noon. It rises in the east and travels in an east-west direction. Rising later in winter than in summer, the sun follows a lower path and it sets earlier. As winter changes into spring and summer, the sun's path moves higher in the sky; it begins to rise earlier and set later.

Procedure

1. Following instructions in the heliodon kit, set up it and demonstrate its use.

2. Review the importance of a southern exposure.

3. Review the determination of available light by subtracting background light from total light readings.

4. Explain how to calculate the percentage of difference in winter and summer light.

$$\%\text{Difference in Available Light} =$$

$$\frac{\text{amount of light in winter at given time}}{\text{amount of light in summer at given time}} \times 100\%$$

5. Supervise data collection.

6. Follow with discussion.

Discussion

1. How does the amount of available light at 9 a.m. in winter compare to the amount of available at the same time in summer? Give the % difference. What about for noon? for 3 p.m.?

   More light is available in the summer. (Students must calculate from data.)

2. In which season is the most light available? Why?

   Summer has the most light available because there is a longer arc for the sun.

3. Is there a time of day when a maximum amount of sunlight is received? When is it?

   Yes; the actual amounts could vary a little due to a variety of factors, but the time of maximum available sunlight is noon.

Instructions

1. Place the solar home facing directly south.
2. Place the light meter on the front of the house.
3. Obtain a background reading.
4. Begin with the light rising in the east on the summer arc and slowly move the light from east to west. Watch what happens to the light meter. Take a reading when the light is positioned at each of the three dots found on the summer arc. These dots correspond to 9 a.m., noon, and 3 p.m. Is there a time when a maximum amount of light is received? Record your findings in the data table. Repeat for the winter arc. Record.

DATA TABLE

TIME OF DAY	SUMMER AVAILABLE LIGHT (Total-Background)	WINTER AVAILABLE LIGHT (Total-Background)	MAXIMUM AVAILABLE LIGHT (Check to indicate maximum)
9 A.M.			
NOON			
3 P.M.			

HELIODON: #5

THE EFFECT OF THE SOLAR ARC ON HEATING

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
2 class periods

MATERIALS:
Heliodon kit
Thermometer
Two 20 - 30 ml beakers (or small glass jars that will sit inside solar house)
Room temperature water
Balance
Worksheet (included)

Objectives

The student will:
1. Measure the amount of heat absorbed by water over a period of time.
2. Calculate the amount of heat stored.
3. Determine the effect of the solar arc on heating.

Background Information

The solar arc is the path the sun takes across the sky from east to west. The winter arc is much shorter and lower than the summer arc. Consequently, there is less total sunlight in winter, and the limited sunlight we do receive comes from a lower angle. Conversely, the summer sun is in abundant supply, and the excess energy which must be prevented from entering and overheating our buildings comes from a higher angle.

This heat from sunlight can be stored by heat-absorbing materials in the building. These materials will then give off this stored heat when the air temperature drops (e.g., at night). Some solar designs use water as a storage material for solar heat; others use air or various building materials. Heat gain in water is measured in calories, but because calories represent discrete amounts of energy, they may be converted to British thermal units or to kilowatthours, units which are more applicable to the topic of home (or other) heating.

A calorie is the amount of heat energy required to raise the temperature of one gram of water by one degree Celsius. (A related concept is that of specific heat capacity, the number of calories of heat required to raise the temperature of one gram of any substance by one degree Celsius. For water, the specific heat capacity is one calorie per gram-degree Celsius.) The Btu, or British thermal unit, is the amount of heat energy required to raise the temperature of one pound of water by one degree Fahrenheit. A kilowatt is one thousand watts of energy and can be used as a unit of electrical energy. A kilowatthour is the number of kilowatts of electricity used in one hour of time. Conversion factors for these units are as follows:

1 cal = 0.000397 Btu
1 Btu = 252 cal
1 kWh = 3410 Btu
1 kWh = 860,000 cal

Procedure

1. Set up and demonstrate use of heliodon.

2. Review accurate reading of thermometer.

3. Explain use of change in temperature of water and specific heat capacity of water to calculate amount of solar heat gained by water in beakers.

4. Explain units of heat energy: calorie, Btu, and kilowatthour. Explain conversion from one unit to another.

5. Lecture/discussion for steps 3 and 4 (above) can be done after activity is begun, while water is collecting heat.

6. Supervise student completion of activity.

7. Follow with discussion.

Discussion

1. Which beaker of water absorbed the most heat energy? Compare students' calculated answers.

   The beaker in the solar greenhouse or sunspace absorbed more energy.

2. Why did one beaker absorb more heat energy than the other?

   More sunlight is available in the greenhouse or sunspace area.

3. What factors affect the amount of heat absorbed by each beaker?

   Some factors are the season of the year (summer arc vs. winter arc), length of time water is exposed to sunlight (related to seasons), and shading factors (if any).

4. What is one difference between our experiment and a real experiment using the sun and a solar home?

   A smaller amount of water is used in this experiment. A larger amount of water requires more heat to warm the water to the same degree. In a solar home designed to use water as the heat-collecting material, extremely large amounts of water are required.

Instructions

1. Mass each beaker before filling with water. Add the same amount of water to each beaker, then mass again. For each beaker, subtract the mass of the beaker from the total mass to determine the mass of the water. Record both masses, carefully noting which is the mass of the water in beaker #1 and which is that in beaker #2.

2. Take temperature readings of the water in both beakers. Record these initial temperatures in the table below.

3. Place beaker #1 in the solar house in the living room next to the window and beaker #2 in the greenhouse or sunspace.

4. Replace the solar house roof. Position the sun at the noon position for the winter arc. Allow the sun to shine from this position for 2 or 3 hours (the longer the time, the better).

5. When the time is up, remove the roof and measure the final temperature of the water. Record the final temperatures of both in the data table.

6. Repeat this procedure for the summer arc. Record both sets of initial and final temperatures in the data table.

7. Calculate the amount of heat energy absorbed by each beaker.
   Amount of heat absorbed = (mass of water in beaker) x $\frac{\text{1 calorie}}{\text{1g} \times 1^\circ}$

   x (final - (initial temperature) = calories

8. Convert these calories to Btu and then to kWh.
   1 calorie = 0.0397 BTU
   1 kWh = 3410 BTU

DATA TABLE

	WINTER		SUMMER	
	Initial Temp.	Final Temp.	Initial Temp.	Final Temp.
BEAKER #1 (Living Room) (Mass$_{Water}$ = ___g)				
BEAKER #2 (Greenhouse) (Mass$_{Water}$ = ___g)				

CALCULATIONS

USE WITH:
Advanced General Science
Environmental Science
Physics
Physical Science

TIME:
1 class period

MATERIALS:
Solar Pathfinder kit
Scissors
Worksheets (included)

SOLAR PATHFINDER: #1

ASSEMBLY AND USE OF A SOLAR PATHFINDER

Objectives

The student will:
1. Assemble the Solar Pathfinder.
2. Use the compass correctly.
3. Adjust the Solar Pathfinder for magnetic declination.
4. Identify the types of shaded areas on a Sunpath Diagram.

Background Information

The Solar Pathfinder is a professional instrument which facilitates rapid solar site analysis any time of the year. The instrument does not need direct sunlight. The Solar Pathfinder can display solar access data for an entire year in a single image. This capability is due to a patented design by which all surrounding objects that will influence collector shading at the site under study are simultaneously displayed in the reflected image on the Pathfinder's dome. Solar access data observed, measured, and recorded with the Solar Pathfinder applies directly to the full range of active and passive solar design exercises. Analysis for winter heating, summer cooling, domestic hot water, and swimming pool systems is made easier, faster, and more accurate.

Procedure

1. At the beginning of class, discuss with the students the following questions:

   a. Why should one be concerned with energy usage?
   b. How many energy saving devices can you name?
   c. How do you know where to place such energy-saving devices?
   d. Do you know of any instruments that can be used to analyze a site for placing energy-saving devices?

2. Demonstrate assembly and use of the Solar Pathfinder.

3. Supervise activity.

4. Follow with discussion.

Discussion

1. Review the procedure for assembling and using the Solar Pathfinder.

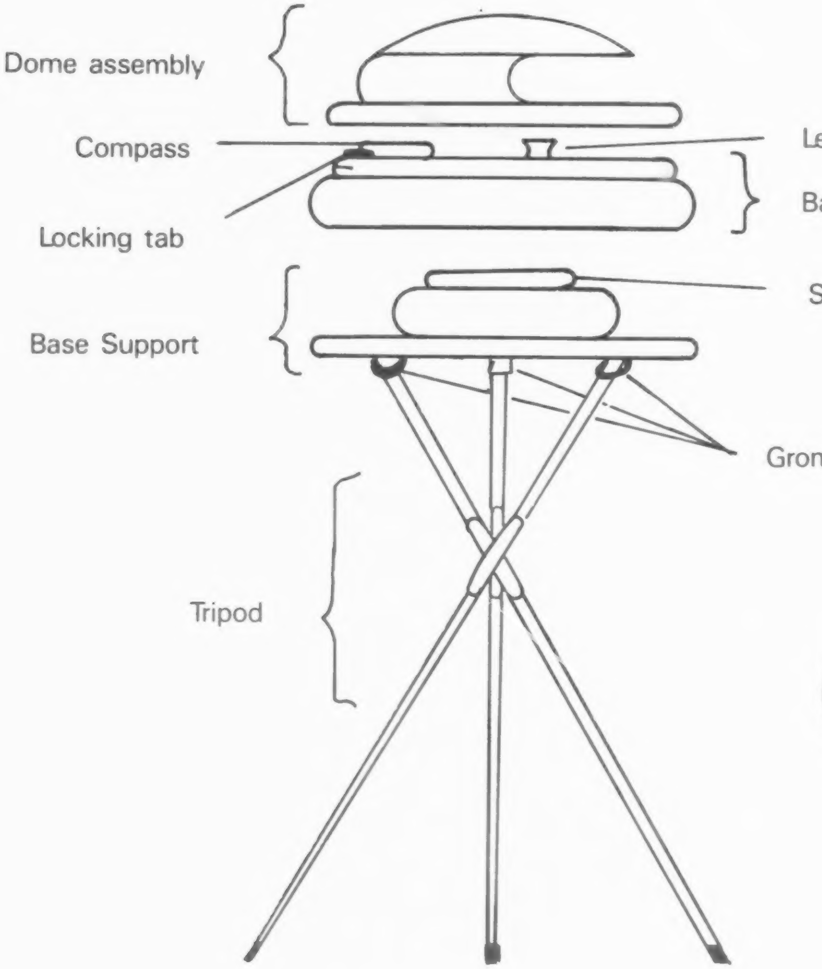
2. Using the Isogonic Chart, what is the magnetic declination for the northernmost corner of Oregon State? Would you move the solar diagram to your left or to your right?

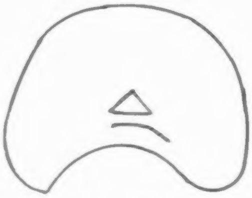
   21°; left.

3. Describe the shaded areas which appeared in the Solar Pathfinder. What features cause these shaded areas? Are there seasonal differences in these features?

4. How might plans to install energy-saving solar devices be affected by the information gained from using this equipment?

ASSEMBLY OF THE SOLAR PATHFINDER


Dome assembly
Compass
Level Triangular pivot
Base
Locking tab
Seat for base
Base Support
Grommets
Tripod



Sunpath Diagram

Instructions

1. Remove and identify each item in the Solar Pathfinder kit.

2. Extend the legs of the tripod.

3. Connect the round knob of the tripod to the grommets on the base.

4. Adjust this part of the assembly to the level position.

5. Place a Solar Pathfinder's Sunpath Diagram onto the base.

6. Check the Isogonic Chart for the appropriate easterly or westerly magnetic declination. (An isogonic chart shows magnetic declination, the difference between geographic and magnetic poles of the earth.)

    a. Notice the maximum easterly or westerly declination for the continental United States is 22°.
    b. Example: The magnetic declination for the tip of East Tennessee is 3-1/2° westerly.

7. Set the Solar Pathfinder for the magnetic declination of your location. Follow this procedure.

    a. Cut out Diagram A and place on the pathfinder.
    b. Locate the white dot on the base.
    c. Place the white dot opposite you.
    d. Locate the brass Sunpath Diagram locking tab and pull it approximately 1/4-inch away from the compass. This will free the pivot and diagram.
    e. Turn the Solar Pathfinder's diagram by moving the pivot.
    f. Move the diagram to the proper declination.
    g. Push the brass locking tab back to the compass; this stops the diagram from moving.
    h. Remove Diagram A.

8. Place the base onto the base support.

9. Rotate the base until the needle on the compass points south. If one is facing south, west is to your right, east is to your left, and north is to your back.

10. Carefully move the base until the bubble is in the center of the pivot. If the base is not level, adjust the legs.

11. Recheck the compass. Is the needle pointing south?

12. Recheck the level. Is the bubble in the center of the pivot?

13. Carefully place the dome assembly on top of the base.

14. For correct observation, your face should be approximately 15 inches above the dome.

15. Identify the shaded areas in the dome assembly.* Is one or more of the shaded areas a building? Is one or more of the shaded areas an evergreen or shrub (for example, a pine tree)? Is one or more of the shaded areas a deciduous (leaf-shedding) tree or shrub? Describe the shading reflected in the dome.

* Only the shaded areas on the Solar Pathfinder's Sunpath Diagram are important.

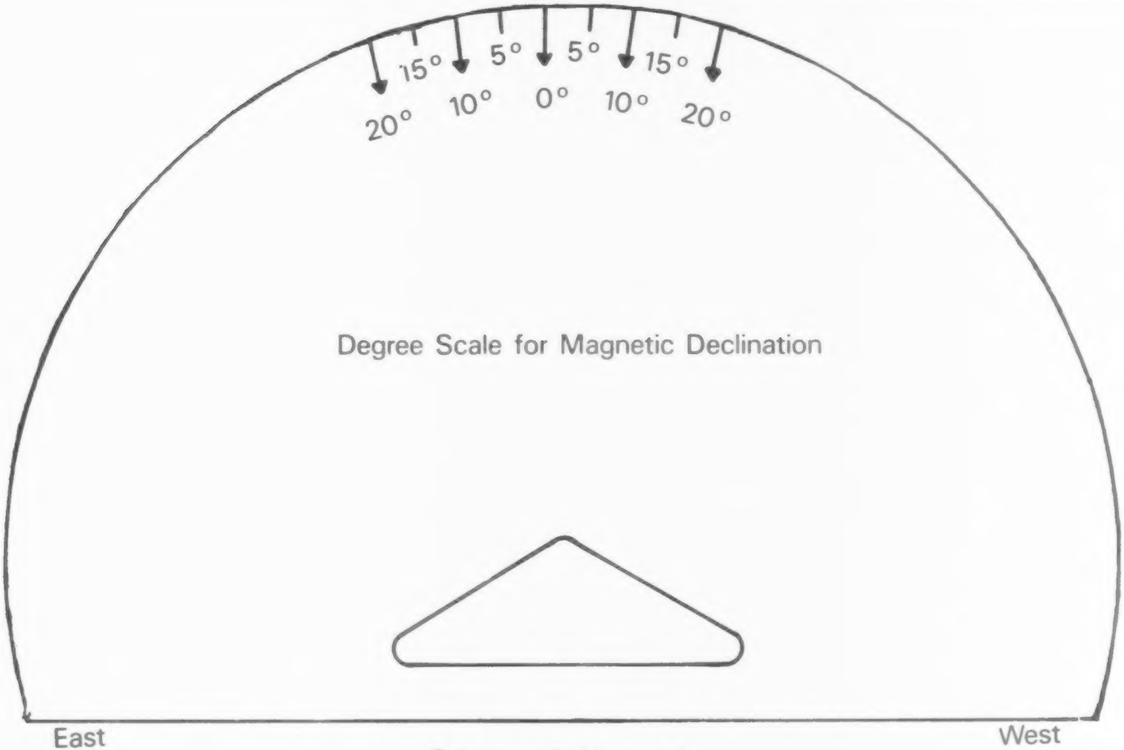
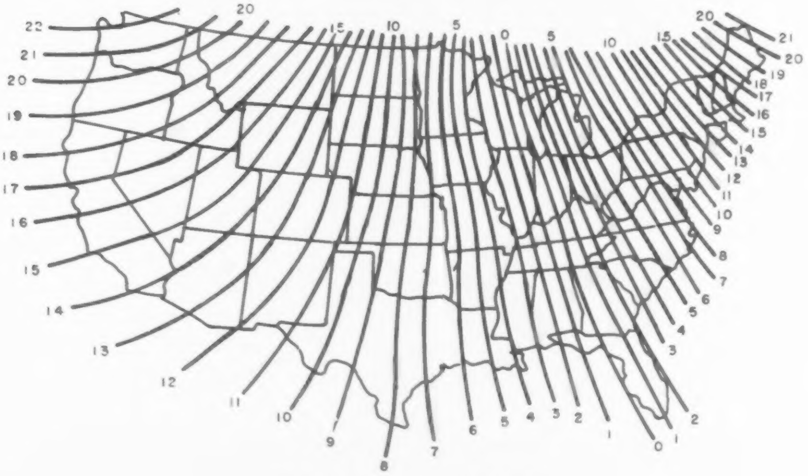

15°
5°
5°
15°
20°
10°
0°
10°
20°
Degree Scale for Magnetic Declination
East
West

Diagram A (cut out)


22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1
2
20
15
10
5
0
5
10
15
20
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3

ISOGONIC CHART
E-DECLINATION-W

SOLAR PATHFINDER: #2

SITE ANALYSIS FOR DOMESTIC SOLAR WATER HEATING

USE WITH:
Advanced General Science
Physical Science
Physics
Environmental Science

TIME:
1 class period

MATERIALS:
Solar Pathfinder kit
Worksheets (included)

Objectives

The student will:
1. Identify the prime solar fraction for a specific orientation and site.
2. Compare the prime solar fraction for each solar diagram.
3. Identify the proper placement for a solar water heating unit.

Background Information

Conservation has become increasingly more important as energy costs have risen. Efforts to save energy and money have led to the development of alternative technologies. A domestic solar water heating unit is an alternative to conventional water heaters, which consume significant amounts of electricity.

However, it is essential to place solar water heating units in the specific sites and orientations necessary to receive the maximum solar energy; only then are these alternative devices cost-effective.

The Solar Pathfinder kit will be used to locate such a site. The Sunpath Diagrams have been developed to simplify the observation, measurement, and recording of the amount of sunlight which will strike a proposed collection surface during a given heating season after the shading factors are taken into account. This amount of sunlight is a percentage of the total available radiation for a given locale and is called the prime solar fraction.

Procedure

1. Discuss the importance of energy conservation.

2. Discuss the use of "free" solar energy to heat water, substituting for a significant portion of the home energy bill.

3. Review the importance of proper placement of solar collectors and use of solar pathfinder to determine proper placement.

4. Define a prime solar fraction and explain how it is determined.

5. Explain criteria for placing solar water heating devices at a certain site and orientation.

6. Supervise activity.

7. Follow with discussion.

Discussion

1. The direction which has the ___________________ prime solar
   (higher or lower)
   fraction should be the direction the solar water heating unit faces.

   Higher.

2. What orientation is recommended for a solar water heating unit for this particular experimental site?

3. What is the purpose of multiplying the total of deciduous trees and shrubs by 2/3?

   The deciduous trees have leaves for approximately 2/3 of the year.

4. What is the purpose of considering trees and shrubs separately from buildings on the data sheet?

   Unlike buildings, trees and shrubs can be cut or removed to another location.

Instructions

1. Choose a site outside the building for testing.
2. Place one of the Sunpath Diagrams onto the base of the Solar Pathfinder.
3. Assemble the Solar Pathfinder. (Refer to activity #1 for directions.)
4. Recheck to see if unit is balanced.
5. Make certain that the compass needle is pointing south and that you are facing south.
6. Compensate for magnetic declination.
7. The viewing position is approximately 15 inches above the center of the dome.
8. If the sunlight is too bright, shade the device with your hands or a paper. The Solar Pathfinder can be used on a cloudy day. Do not use the unit in the rain. Be careful not to move the device.
9.
    a. Count the number of solid dots in the shaded area caused by deciduous trees or shrubs. Multiply this number by 2/3. Record on the data sheet.
    b. Count and record the number of solid dots in the shaded area caused by evergreen trees or shrubs.
    c. Count and record the number of solid dots in the shaded area caused by a building or buildings.
    d. Total the number of solid dots in the shaded areas and multiply by two. Remember only 2/3 of the deciduous trees or shrubs total should be used.
    e. To find the prime solar fraction of the shaded areas, subtract the answer in "d" from 100. Record on the data sheet. To check the prime solar fraction, complete the following:
    f. Count the number of solid dots in the clear area. Record on the data sheet.
    g. Multiply the number of solid dots shaded by a deciduous tree by 2/3. Subtract this number from the deciduous tree total. Add this value to the total number found in "f."
    h. Multiply the total in "g" by two. This is also the prime solar fraction.
    i. If the answers in "e" and "h" are not similar, recheck number 9 of the procedure.
10. Repeat number 9 of the procedure for each of the solar diagrams.

Data Sheet
Shaded Area

	WEST	W-NW	SOUTH	SE	W-SW	E-SE	E-NE	SW	S-SW	S-SE	EAST	NORTH	NE
D#x 2/3													
E#													
B#													
Total													
Prime Solar Fraction													

	WEST	W-NW	SOUTH	SE	W-SW	E-SE	E-NE	SW	S-SW	S-SE	EAST	NORTH	NE
Clear Area Total													
Prime Solar Total													

Prime Solar Fraction = 100 - (Shaded Area Total X 2)
Prime Solar Fraction = (Clear Area Total + D# - [D# X 2/3)]) (2)

*Deciduous trees and shrubs - D
*Evergreen trees and shrubs - E
*Buildings - B
#Number

USE WITH:
Advanced General Science
Physics
Environmental Science
Physical Science

TIME:
1 class period (groups of 2-4 students)

MATERIALS:
Solar Pathfinder kit
Worksheet (included)

SOLAR PATHFINDER: #3

SITE ANALYSIS FOR ACTIVE SPACE HEATING

Objectives

The student will:
1. Determine the best orientation and placement for active space heating.
2. Identify the prime solar fraction for specific orientations and site.
3. Compare the prime solar fraction for each solar diagram.
4. Decide if active space heating could provide all the needed heat for home heating at the chosen site.

Background Information

Ancient people learned to build their homes so that the heat of sunlight could be utilized to the best advantage. Those methods of building used solar energy passively. Technology is presently available to combine solar energy with active systems for even more use of solar heat.

In the Valley, use of active solar space heating is feasible in many locations. Determination of the feasibility of this technology for heating homes or other buildings can be made using the Solar Pathfinder and procedures similar to those in the solar water heater activity. The Sunpath Diagrams provide a set of 50 square symbols for the analysis of active space heating potential for October through March on a true south collection surface elevated at an angle equal to the latitude plus 15 degrees. An active space heating system uses electrically powered pumps, valves and thermostats to transfer heat from collectors to the appropriate area.

Procedure

1. Discuss some examples of ways man has used solar energy in the past.

2. Discuss the use of solar energy assisted by other power sources for more possibilities for using this "free" energy and conserving those other power sources.

3. Review use of Solar Pathfinder in water heater activity #2.

4. Explain the criteria for feasibility of utilization of active space heating.

5. Use map to show students latitude of location.

6. Supervise activity.

7. Follow with discussion.

Discussion

1. The direction which has the ______________________ prime solar
(higher or lower)
fraction should be the direction the active solar space heating system faces.

   Higher.

2. What orientation is recommended for an active solar space heating system for this particular site?

3. Why is the number of open squares shaded by deciduous trees or shrubs multiplied by one third?

   The deciduous trees have no leaves for about 1/3 of the year; it is these winter months in which heating is needed.

4. Why are trees considered differently from buildings?

   Unlike buildings, trees and shrubs can be cut down or transplanted to other locations.

Instructions

1. Choose a site outside the building for testing.

2. Place one of the Sunpath Diagrams onto the base of the Solar Pathfinder.

3. Assemble the Solar Pathfinder as previously directed.

4. Recheck to see if unit is balanced.

5. Make certain that the compass needle is pointing south and that you are facing south.

6. Compensate for magnetic declination.

7. The viewing position is approximately 15 inches above the center of the dome.

8. If the sunlight is too bright, shade the device with your hands or a paper. The Solar Pathfinder can be used on a cloudy day. Do not use the unit in the rain. Be careful not to move the device.

9. a. Count the number of open squares in the shaded area of the solar diagram caused by deciduous trees and shrubs. Multiply this number by 1/3 and record on data sheet. Do not record a number if no deciduous trees are producing a shadow on the diagram.
   b. Record the number of open squares in the shaded area of the solar diagram caused by an evergreen tree or shrub. Record a number only if the image of an evergreen occurs in the pathfinder unit.
   c. Record the number of open squares in the shaded area of the solar diagram caused by buildings. Record only if the image of a building occurs in the pathfinder unit.
   d. Total the number of open squares in the shaded areas and multiply by two.
   e. To find the solar percentage fraction of the shaded areas, subtract the total number derived in part "d" from 100. Record on data sheet. To check the solar percentage fraction, use the following method:
   f. Count the number of open squares in the clear area. Record on the data sheet.
   g. Refer to deciduous trees on your data sheet. Subtract the derived deciduous tree number from the actual deciduous tree count in the shaded area. Add this value to the clear total.
   h. Multiply the total in "g" by two; this is also the solar percentage fraction. If the answers are not similar in "e" and "h," recheck number 9 of the procedure.

10. Repeat number 9 of the procedure for each of the solar diagrams with open squares.

Data Sheet
Shaded Area

	WEST	W-NW	SOUTH	SE	W-SW	E-SE	E-NE	SW	S-SW	S-SE	EAST	NORTH	NE
D#x 2/3													
E#													
B#													
Total													
Prime Solar Fraction													

	WEST	W-NW	SOUTH	SE	W-SW	E-SE	E-NE	SW	S-SW	S-SE	EAST	NORTH	NE
Clear Area Total													
Prime Solar Total													

Prime Solar Fraction = 100 - (Shaded Area Total X 2)

Prime Solar Fraction = (Clear Area Total + [D# - (D# X 1/3)])(2)

*Deciduous trees and shrubs - D
*Evergreen trees and shrubs - E
*Buildings - B
#Number

USE WITH:
Advanced
General Science
Physical Science
Environmental
Science
Physics

Time
1 day (9:00 a.m. - 3:00 p.m. on the hour)

MATERIALS:
Solar Pathfinder kit
Tape
Silicon solar cell
Multitester
Milliamp scale
Cardboard
Wire connectors
Protractor
Worksheet (included)

SOLAR PATHFINDER: #4

ORIENTATION OF SOLAR CELLS FOR ELECTRICAL ENERGY

Objectives

The student will:

1. Record the amperage produced by the solar cell at a particular site and direction.
2. Identify the prime solar fraction for a specific orientation and site.
3. Compare the prime solar fraction for each solar diagram.
4. Compare the prime solar fraction for each solar diagram with the amperage produced by a silicon solar cell between the hours of 9 a.m. and 3 p.m.

Background Information

A solar cell is a silicon semiconductor device which converts light energy directly to electricity. It is properly called a photovoltaic cell. By converting sunlight into electrical current these devices make solar energy usable for many tasks for which we now use other sources of energy.

A typical 2.5 x 5 cm battery cell will produce 0.42 volt of usable current. The voltage produced by a solar cell is roughly 0.45 volt regardless of the area of the cell. The power generated is affected by the load resistance (circuit powered by cell strength of sunlight and temperature). Solar cells may be connected in series to produce more voltage and in parallel for more current.

The solar cell acts very much like a constant current source over most of its operating range. The cell will not destroy itself. Even if the load resistance became very low, the current would not become excessive. The silicon solar cell's theoretical limit of energy conversion efficiency is about 25 percent. By comparison, the ordinary automobile engine has an energy conversion efficiency of only about 20 percent.

Procedure

1. Review the Solar Pathfinder's use.
2. Describe the structure and function of a solar cell.
3. Relate orientation of solar cells and production of current from sunlight.
4. Supervise activity.
5. Follow with discussion.

Discussion

1. Compare the prime solar fraction and the direction with the amperage total-direction. Is the higher solar amperage-direction the same as the higher prime solar fraction-direction? Is the lower solar amperage-direction the same as the lower prime solar fraction-direction?
2. Can the solar diagrams for domestic water heating be used for placing solar cells for energy use? Why? Is one day of experimentation enough to decide this question? How can this research be made more valid?
3. Describe a solar cell and how it works.
4. As follow-up, go to the library and find out ten uses of solar cells for electrical energy. Be specific.
5. What are some implications for use of this technology?

Instructions

1. For best results, start this activity on a clear day at 9 o'clock. Only the part of the activity that uses a solar cell needs to be completed under these conditions. Calculations may be done later.

2. Choose a site outside the building for testing.

3. Place one of the Sunpath Diagrams onto the base of the Solar Pathfinder.

4. Assemble the Solar Pathfinder as previously directed.

5. Recheck to see if the unit is balanced.

6. Compensate for magnetic declination.

7. Make certain that the compass needle is pointing south and that you are facing south.

8. If the sunlight is too bright, shade the device with your hands or paper. The Solar Pathfinder can be used on a cloudy day. Do not use the unit in the rain. Be careful not to move the device.

9. a. Count the number of solid dots in shaded areas caused by deciduous trees or shrubs. Multiply the total by 2/3. Record on the data sheet.
    b. Record the number of solid dots in the shaded area caused by evergreen trees or shrubs.
    c. Record the number of solid dots in the shaded area caused by buildings.
    d. Total the number of solid dots in shaded areas and multiply by two. Remember, use only 2/3 of the deciduous trees or shrubs total. Record on the data sheet.
    e. To find the solar percentage fraction of the shaded areas, subtract the total number derived in part "d" from 100. To check your solar percentage fraction, use the following method.
    f. Count and record the number of solid dots in the clear area.
    g. After multiplying the solid dots in the deciduous tree area by 2/3, subtract this value from the deciduous tree total. Add this value to the clear total.
    h. Multiply the total in "g" by two; this is also the solar percentage fraction.
    i. If the answers in "e" and "h" are not similar, recheck number 9 of the procedure.

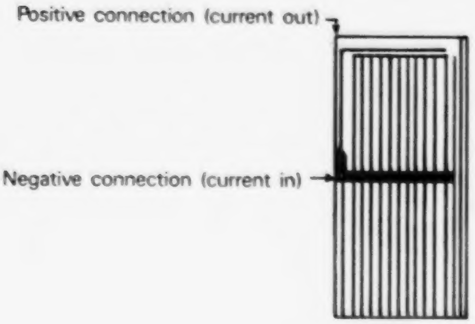
10. Repeat number 9 of the procedure for each of the Sunpath Diagrams.

11. Remain in the same location for this part of the activity. Elevate the solar cell at an angle equal to the latitude of your location plus 15 degrees. Mount the solar cell so that it will stay at this angle. Be careful with the solar cell so that the connections are not damaged.

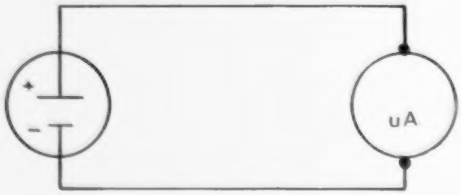
12. Place the direction scale on a piece of cardboard.

13. Place the solar cell on the direction scale. Use a piece of cardboard bent at the correct angle to support the solar cell. Orient the direction scale to the south by using the Solar Pathfinder compass.

14. Connect the multitester to the silicon cell. Refer to the


Positive connection (current out)
Negative connection (current in)
Photosensitive surface

solar cell



circuit diagram

15. a. Place the mounted solar cell on the direction scale to correspond with the solar diagrams directions. Look at the sheet. Do not stand in the light affecting the solar cell.
    b. Turn on the multitester and record the amount of amperage on the data sheet.

16. Repeat number 15 of the procedure for every direction of the solar diagram.

17. Repeat 15 and 16 for 10 a.m., 11 a.m., noon, 1 p.m., 2 p.m., and 3 p.m.

18. Total the amperage for each direction.

19. List in progression the prime solar fractions.

20. List in progression the amperage total and the direction.

Data Sheet
Shaded Area

	WEST	W-NW	SOUTH	SE	W-SW	E-SE	E-NE	SW	S-SW	S-SE	EAST	NORTH	NE
D#x 2/3													
E#													
B#													
Total													
Prime Solar Fraction													

	WEST	W-NW	SOUTH	SE	W-SW	E-SE	E-NE	SW	S-SW	S-SE	EAST	NORTH	NE
Clear Area Total													
Prime Solar Total													

Prime Solar Fraction = 100 - (Shaded Area Total X 2)

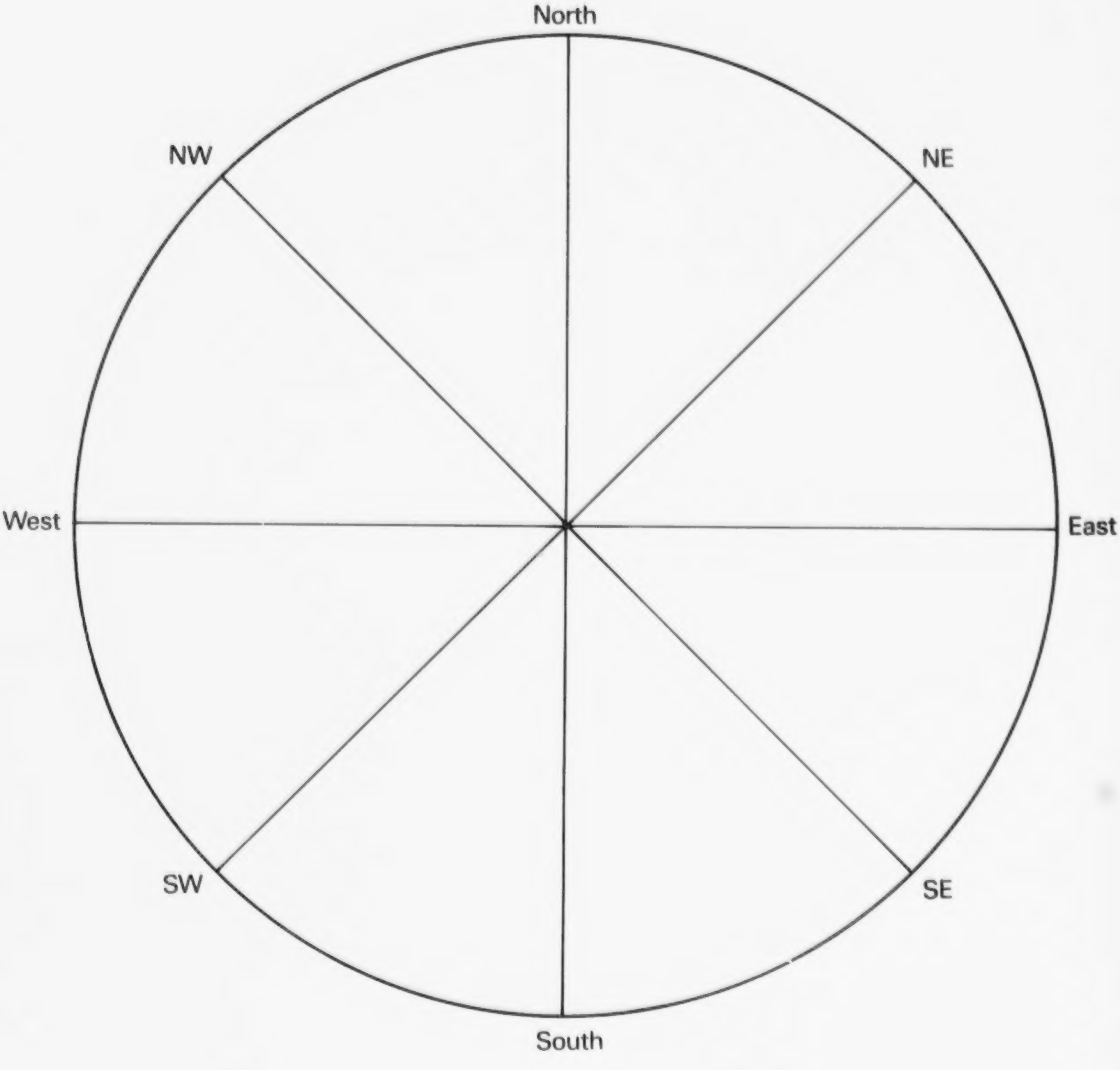
Prime Solar Fraction = (Clear Area Total + D# - [D# X 2/3)]) (2)

*Deciduous trees and shrubs - D
*Evergreen trees and shrubs - E
*Buildings - B
#Number

Data Sheet
Amperage - Direction

	WEST	W-NW	SOUTH	SE	W-SW	E-SE	E-NE	SW	S-SW	S-SE	EAST	NORTH	NE
9 a.m.													
10 a.m.													
11 a.m.													
12 noon													
1 p.m.													
2 p.m.													
3 p.m.													
Total													

SOLAR CELLS FOR ELECTRICAL ENERGY


North
NW
NE
West
East
SW
SE
South

Prime solar fraction progression list:

Amperage total and direction progression list:

Comparison of the prime solar fraction progression list and the amperage total and direction progression list.

COMPASS: #1

MEASURING THE SUN'S POSITION

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
1 class period

MATERIALS:
Compass
Protractor
Worksheets (included)

Objectives

The student will:

1. Define solar altitude, arc, and azimuth.
2. Construct a diagram showing the sun's path across the sky.
3. Describe seasonal differences in the solar arc.

Background Information

From earth, the sun appears to rise in the east and set in the west. The daily path the sun travels across the sky is called the solar arc. The height of the sun's position is known as its altitude, and its direction is known as its azimuth.

On June 21, the summer solstice, the sun reaches its highest point in the sky. On December 21, the winter solstice, the sun's peak is at its lowest. The length of the solar arc (or the distance the sun travels from east to west across the sky) is greatest on the summer solstice and shortest on the winter solstice.

In the Tennessee Valley, on the summer solstice (June 21), the sun rises 15 degrees north of due east, climbs at noon to a peak of 78 degrees altitude, and sets at 15 degrees north of due west. On December 21, the winter solstice, the sun rises 15 degrees south of due east, reaches a noon peak of 32 degrees altitude, and sets at 15 degrees south of west.

The summer sun gives an abundant supply of sunlight, but the winter sun gives a limited supply of sunlight due to its shorter and lower arc. These are important considerations when planning to utilize solar collecting devices or to incorporate solar design elements into a home or other building.

Procedure

1. Discuss seasonal differences in the path of sun across the sky, including the terms solar altitude, arc, and azimuth and solstice.

2. Demonstrate measuring angles to find solar altitude and azimuth.

3. Supervise activity.

4. Follow with discussion.

Discussion

1. How would you construct a diagram for another season?

   (Use the information on the summer and winter arcs.)

2. Compare the amounts of sunlight received by the southern exposure of a building in the summer and winter seasons. Can you name some ways to construct the south wall to take maximum advantage of these seasonal differences?

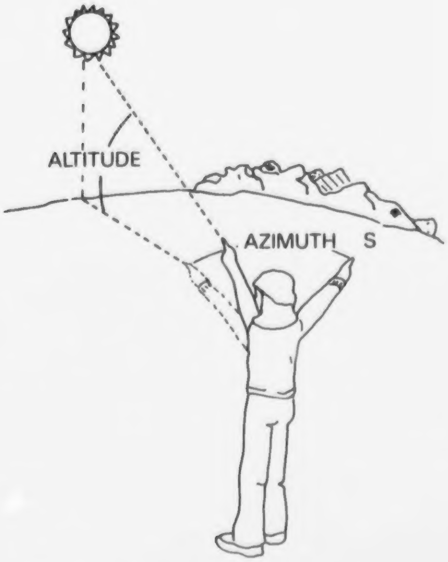
Instructions

1. Find the solar altitude by measuring the angle between the sun and the horizon. (See Diagram #1.) Record the approximate angle here:_______

2. To find the sun's azimuth, locate true south using a compass. Then measure the angle between the line pointing true south and the line pointing to the horizon. (See Diagram #1.) Record the approximate angle here:_______

3. Using these two measurements, construct a diagram showing the sun's path across the sky for the particular season in which the measurements were taken. (See Diagram #2.) Draw diagram in space below.

Diagram 1

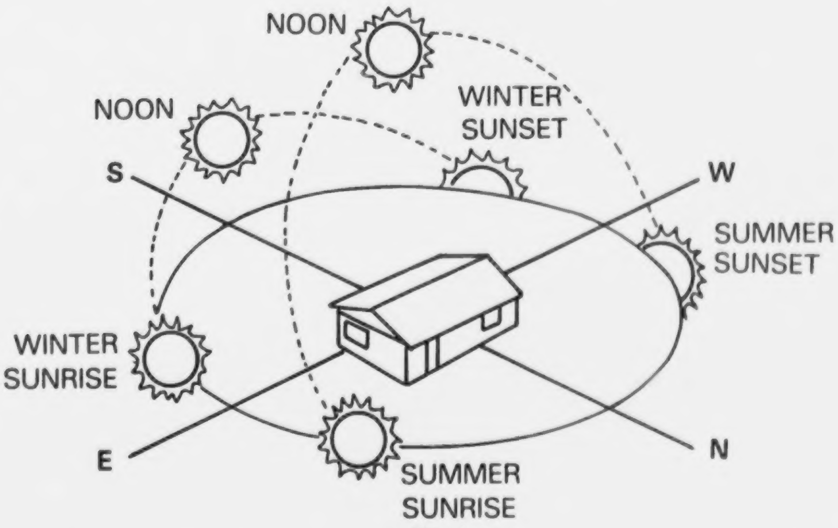

ALTITUDE
AZIMUTH
S

Measuring The Sun's Position

The solar altitude is measured by the angle between the sun and the horizon; the azimuth is the sun's position measured from the south.

(Adapted from *The Solar Home Book* by Bruce Anderson with Michael Riordan with the permission of Brick House Publishing Co., Inc.)

Diagram 2


NOON
NOON
WINTER SUNSET
S
W
SUMMER SUNSET
WINTER SUNRISE
E
N
SUMMER SUNRISE

COMPASS: #2

COMPARISONS OF SOLAR HEAT GAIN IN COLLECTORS OF DIFFERING EXPOSURES

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
1-2 class periods

MATERIALS:
Compass
4 600-ml beakers or clear glass jars
4 thermometers
Room temperature water
Worksheet (included)

Objectives

The student will:

1. Convert temperature change to units of energy gained.
2. Compare the amounts of heat energy gained from sunlight at different exposures.
3. Determine which exposure gains the most heat.
4. Identify ways to make the demonstration more valid or comprehensive.

Background Information

Solar energy is often used for heating water in homes, home heating systems in which heated water gives off its heat into the air to warm the home, or for other systems using hot water. Water is a good substance for short-term storage or for transport of heat energy.

An easy way to demonstrate and compare solar heat gains is to find the temperature changes of volumes of water which have been exposed to sunlight for a period of time. If different orientations receive differing amounts of sunlight, the amounts of heat energy absorbed by collectors at these different exposures should also differ. Given the proper conversion factors, the degrees of temperature changes can be converted into units of energy.

The amount of energy necessary to raise the temperature of one gram of water by one degree Celsius is called a calorie. (This definition of the unit the calorie is equivalent to the specific heat capacity of water; that is, the specific heat capacity of any substance is the energy required to raise the temperature of one gram of that substance by one degree Celsius, and for water this quantity is one calorie.) In science, the calorie is the unit of choice, but another unit is used for the energy to heat and cool water and air in manmade systems.

Utilities, technicians, and engineers use the British thermal unit, or Btu, in this capacity. A British thermal unit is the energy required to raise the temperature of one pound of water by one degree Fahrenheit.

Oftentimes, Btu's are converted to kilowatthours (kWh) to express the amount of electrical energy required to produce a given amount of heating or cooling. The conversion factors for these units follow.

1 cal = heat energy to raise temperature of 1g H_2O by 1°C *
1 Btu = heat energy to raise temperature of 1 lb H_2O by 1°F
1 cal = 0.00397 Btu   1 Btu = 252 cal
1 kWh = 3410 Btu   1 Btu = 0.000293 kWh

*Remember that 1g H_2O has a volume of 1 ml or 1 cc.

The literature on solar heating systems uses all these units, particularly the Btu and the kWh. Familiarity with these units and their relationships is a necessity.

Procedure

1. Review importance of proper orientation of solar collectors for maximum energy gain.

2. Discuss heat gain/loss by water (in nature, in manmade systems, especially in solar energy systems).

3. Explain concepts and use of calorie, Btu, and kWh. (If students have already covered this material, a review will suffice. If this has not been previously taught, a class period may be required to teach this background.)

4. Explain instructions to students and distribute materials.

5. Supervise activity. Review material while water heats in sun. Help students with calculations after data are collected.

6. Follow with discussion.

Discussion

1. Based on the data collected from this experiment, which wall of the school receives the most sunlight?

   The south-facing wall receives the most sunlight. (Compare data.)

2. Which wall would be best suited for placement of a solar device?

   The south wall, because it receives the most energy.

3. Is there a way to increase the amount of energy gained by the water?

   Since various colors absorb or reflect light, different colors of paper around the jar or beaker may affect the amount of heat absorbed.

Instructions

1. Carefully measure 500 ml of water into each of the 4 containers. Place a thermometer in each. Record the initial temperature of the water. (Note: Start with room temperature water.)

2. Place one beaker in the sunshine at the walls of the school building which face north, south, east, and west. Allow each beaker to stand in the sunlight at each exposure for one hour. Record the final temperatute reading.

3. Subtract the initial temperatures from the final temperatures to find the temperature differences. Record.

4. Calculate the number of calories of energy gained by each of the beakers of water. Use the space at the bottom of the page. Heat gained (calories) = (mass water) (specific heat capacity of water) (temperature difference)
   $= g \times \frac{1 \text{ calorie}}{1 \text{ g} \times 1°\text{C}} \times °\text{C}$
   Record.

5. Convert calories for each to Btu's and kWh's. Record.

DATA TABLE

Exposure	Initial Temp. °C	Final Temp. °C	Temp. Difference. °C	Calories Gained	Btus Gained	kWh Gained
NORTH						
EAST						
SOUTH						
WEST						

CALCULATIONS

USE WITH:
General Science
Physical Science
Environmental
Science

TIME:
1 class period

MATERIALS:
Compass
Worksheet
(included)
Sun Finder Diagram
(Found at the
end of this
unit)

COMPASS: #3

SITE EVALUATION FOR LOCATING A SOLAR HEATING SYSTEM

Objectives

The student will:
1. Determine the orientation of the exterior walls of the school.
2. Determine which wall is most south-facing and its degree of variance from true south.
3. Compare these data to observations on amounts of sunlight hitting walls.

Background Information

When considering the use of energy-saving solar collectors, careful evaluation of possible locations must be made. The collectors must be oriented so that they receive the greatest possible solar energy. To receive maximum amounts of sunlight throughout the year, the southern exposure of a building and/or the solar collecting devices should be oriented as close to true south as possible. If this orientation is not feasible, the direction may vary by up to 30 degrees east or west of south, resulting in only about a 10 percent reduction of the amount of available sunlight. Any deviation greater than 30 degrees from true south may significantly affect the energy collection of the system.

Procedure

1. Discuss the importance of orienting solar collection devices to maximize energy collection.

2. Explain instructions; demonstrate use of Sun Finder Diagram and compass.

3. Divide class into groups and direct groups to major exterior school walls having different orientations.

4. Follow with discussion.

Discussion

1. Which school walls face north? east? west? south?

2. How many degrees east/west of true south is the south-facing wall?

3. If variance from true south cannot exceed 30 degrees east or west without seriously affecting the ability of a solar device located there to collect heat energy, is the southern wall of the school a suitable place for a solar heating device?

4. Ask the students to compare the data collected on the orientation of the school's walls to their observations of the amounts of sunlight hitting the respective walls. East-facing walls are exposed to morning sunlight but shadowed in the afternoon. The opposite is true for western walls. Students may have observed that walls with a southern exposure receive sunlight for more hours of the day throughout the year.

5. Ask the students for ideas as to how it might be demonstrated that the wall whose orientation is nearest to true south receives more solar energy than other walls.

Instructions

1. Using the compass, determine the orientation of at least four walls of your school building that have different exposures, as directed by instructor. Record data on table.

2. Using the Sun Finder, determine the number of degrees east or west of true south that the wall deviates. Record data.

3. Observe exposure of each wall to sunlight. Recall each wall's exposure at other times of day if possible. Describe on table below.

DATA TABLE

WALL	DESCRIBE LOCATION OF WALL	ORIENTATION OF WALL	DEGREES OF VARIANCE	DESCRIBE EXPOSURE TO SUNLIGHT
1				
2				
3				
4				
OTHER				

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
2 class periods

MATERIALS:
Compass
4 600-ml beakers
clear quart jars
White, black, yellow
construction paper
Scissors
Tape
Room temperature water
Worksheet (included)

COMPASS: #4

ABSORPTIVE COLORS FOR SOLAR COLLECTION

Objectives

The student will:
1. Select colors that could be used to absorb more heat energy from sunlight.
2. Identify those colors that do not promote heat absorption from sunlight.
3. Calculate the temperature difference or amount of heat absorbed by the various colors.

Background Information

If the south side of a building receives the most sunlight, it is the best location for a solar heating system. Besides the location of the system, the color of a solar collector affects the amount of heat it absorbs. (Think of a black asphalt surface on a hot day.) The effect color has on the amount of heat energy collected can be demonstrated by using colored paper around containers of water.

Procedure

1. Review importance of proper orientation for maximum solar gain.
2. Discuss color's effects on solar gain.
3. Explain instructions.
4. Direct activity and help students with calculations.
5. Follow with discussion.

Discussion

1. Which beaker/jar absorbed the most heat or had the largest temperature change?

   The beaker covered with the black paper.

2. Which beaker/jar absorbed the least heat or had the smallest temperature change?

   The beaker covered in white paper.

3. Did the yellow color affect the amount of heat absorbed? Compare it to the uncovered or clear.

   Yellow beaker absorbs more heat than clear beaker.

4. Which color would be the best color for a solar device?

   Black absorbs more light and therefore more heat energy.

5. Rank the colors from most effective to least effective.

   Black, yellow, clear, and white.

6. Speculate on the effect of other colors. (This could be an extension of this activity and could be done at school or at home.)

Instructions

1. Carefully measure 500 ml water into each of the 4 containers. (Remember, the mass of 1 ml H_2O is 1 gram.) Record the mass of the water in each beaker in the data table.

2. Now wrap a beaker with black paper, one with white paper, and one with yellow paper, and leave one uncovered or clear. A small piece of tape will hold the paper together.

3. Measure the initial temperatures of the water.

4. Locate the south wall of the building with the compass. Use the Sun Finder to locate true south so the beakers will be oriented in this direction.

5. Place the beakers in the sunlight for at least one hour. (Longer times are better.)

6. At the end of the hour measure the temperature of the water in each container. Record.

7. Calculate the amount of heat absorbed by the water in each. Record.

Heat gained =	(Mass H_2O)	(Specific heat capacity of water)	(Temperature change)
(calories)	(grams)	(1 cal/g x °C)	(°C)

8. Convert each calculation of calories of gained to Btu and kWh.
   1 cal = 0.00397 Btu
   1 kWh = 3410 Btu

ABSORPTIVE MATERIALS FOR SOLAR USE

	Black	White	Yellow	Clear
Final Temperature, °C				
Initial Temperature, °C				
Mass of Water				
Energy in Calories				
Energy in Btu				
Energy in kWhs				

CALCULATIONS

USE WITH:
General Science
Physical Science
Environmental Science

TIME:
1-2 class periods

MATERIALS:
Compass
Scissors
Glue
Marking pens
Cardboard
Worksheet (included)

COMPASS: #5

BUILDING SHAPE AFFECTS THE USAGE OF SOLAR ENERGY

Objectives

The student will:
1. Design houses of various shapes and evaluate them in terms of solar advantage or disadvantage.
2. Determine if position of house in relation to south affects solar gain or advantage.
3. Design house eaves that reduce solar gain in summer and increase solar gain in winter.

Background Information

The shape of a building also affects how much of the available solar energy can be used. The longer the east/west axis of a building is, the more surface area faces south. A long narrow building with a broad south face allows sunlight to enter more parts of the interior and increases seasonal control over solar energy when compared to a building with a long north/south axis (Diagram 1). Increasing the height of a building is another way of increasing southern exposure. Two or more stories can increase the number of rooms which border the south wall and may have advantages for natural interior air circulation (Diagram 2).

The amount of surface area exposed to sunlight can be reduced by increasing the overhang of the eaves of the roof of a building. By extending the eaves, the amount of undesirable solar gain can be reduced.

Procedure

1. Review importance of orientation for solar energy usage. Review seasonal differences in solar arc.

2. Demonstrate construction and use of model homes for activity.

3. Direct activity.

4. Follow with discussion.

Discussion

1. Which house designs produce the most solar gain when faced south?

   Those with greatest surface area facing south.

2. Does changing the position or orientation of the house affect the solar gain? How?

   Yes. Solar gain can be reduced by placing the house in another orientation.

3. What recommendations would you make to a builder who is building a large number of houses in a subdivision?

   If solar gain is important, the layout of the subdivision should be such that house shapes and orientations will take advantage of the sun.

4. Should houses always be designed so that large surface areas are exposed to the sun?

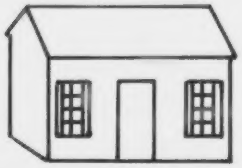
   No. In sunny southern areas, houses could be too hot!

5. What design features of a house could reduce solar gain?

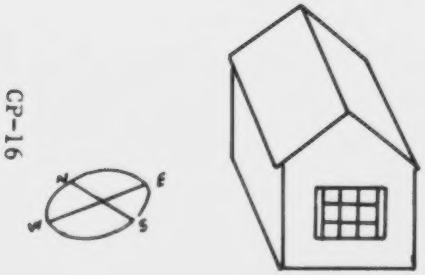
   Longer over-hanging eaves of roofs, windows covered by awnings, and orientation of windows.

CP-16

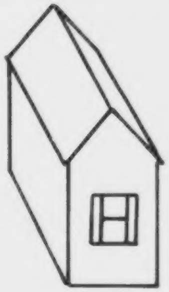
Diagram 1



Narrow Rectangle
Long east-west axis gives best southern exposure to sunlight gains most heat from the sun

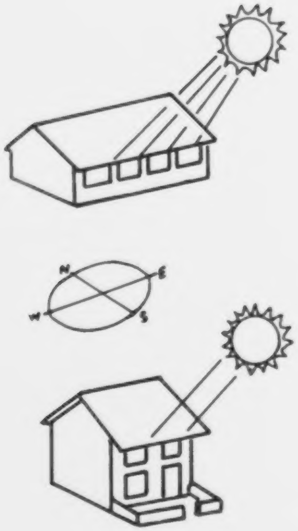


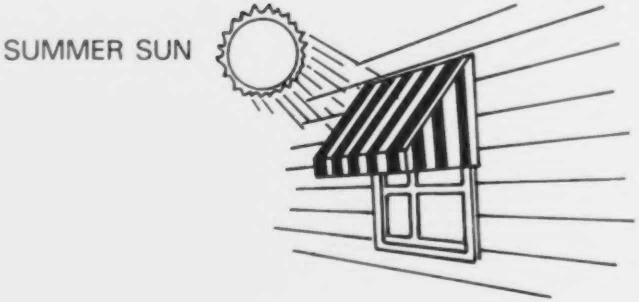
Broad Rectangle or Square
Equal north-south, east-west axis gives moderate southern exposure to sunlight, gains moderate heat from the sun



Narrow Rectangle
Long north-south axis gives poor southern exposure to sunlight gains least heat from the sun

Diagram 2





WORKSHEET

Instructions

1. Build model homes with the following shapes: narrow rectangle, broad rectangle, square, two-story rectangle. (Refer to Diagram 1.)

   NOTE: All houses should be built to the same scale so that surface area measurements can be taken and compared. Be sure to make houses large enough to work with outside.

2. Find the south wall of the school building with the compass.

3. Take all house models outside and place facing (fronts toward) south. Determine which house receives most sunlight: measure the amount of surface area covered by sunlight. Record in table below.

4. Turn each house so that each side has a southern exposure. Measure the surface area exposed to sunlight each time the position is changed. (This is to compare amounts of exposure for differing orientations.) Record here.

5. Tape or glue extended eaves onto each model. Remeasure the areas of sunlight as in #3 and #4 above. Record.

DATA TABLE

	SURFACE AREAS			
HOUSE	FRONT	RIGHT	BACK	LEFT
#1				
#2				
#3				
#4				

HOUSE WITH EXTENDED LEAVES	FRONT	RIGHT	BACK	LEFT
#1				
#2				
#3				
#4				

SUN FINDER

Find the exact Direction for your Solar System

WHAT YOU NEED

1. This page
2. Compass

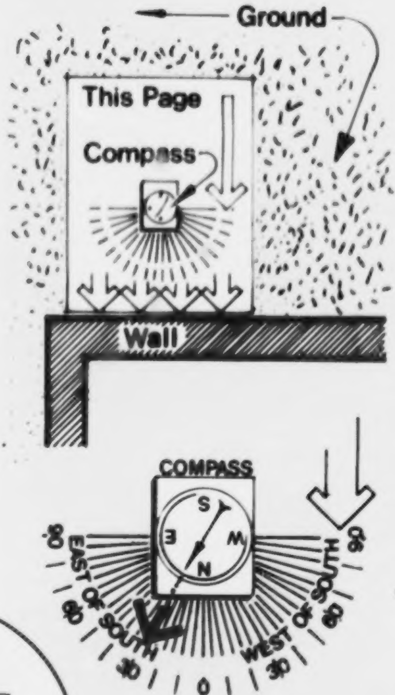
WHERE TO PLACE

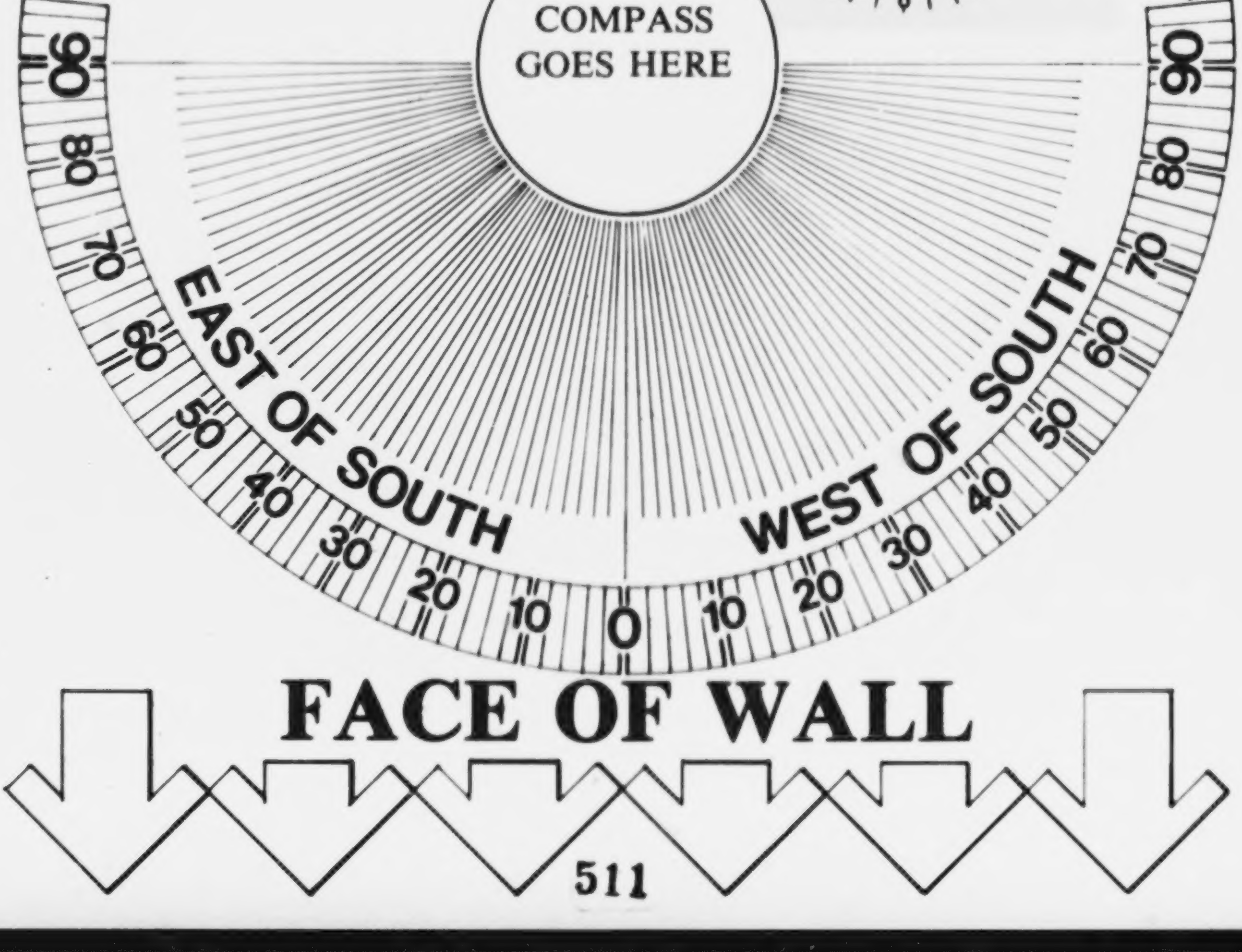
1. Using the compass, decide which wall faces closest to south
2. Place the arrows at the bottom of this page against the face of the south wall
3. Put your compass exactly in the center of the circle marked "COMPASS GOES HERE"

HOW TO USE

1. The compass needle will point to an angle printed on this page
2. This angle will be either east or west of south
3. This will tell you how many degrees off south your wall faces

Example


Ground
This Page
Compass
Wall
COMPASS
S
W
N
E
90
EAST OF SOUTH
60
30
0
30
WEST OF SOUTH
60
90


COMPASS GOES HERE
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
EAST OF SOUTH
WEST OF SOUTH
FACE OF WALL